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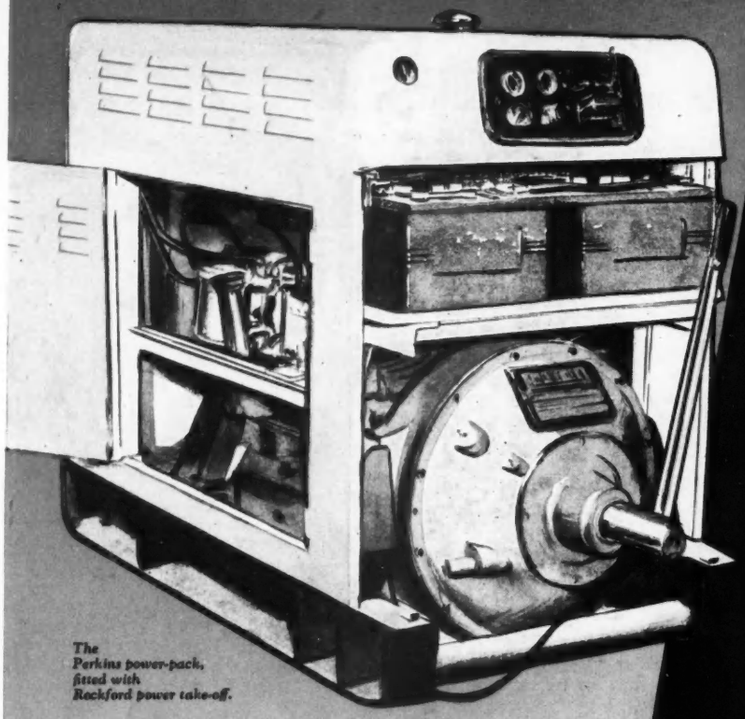

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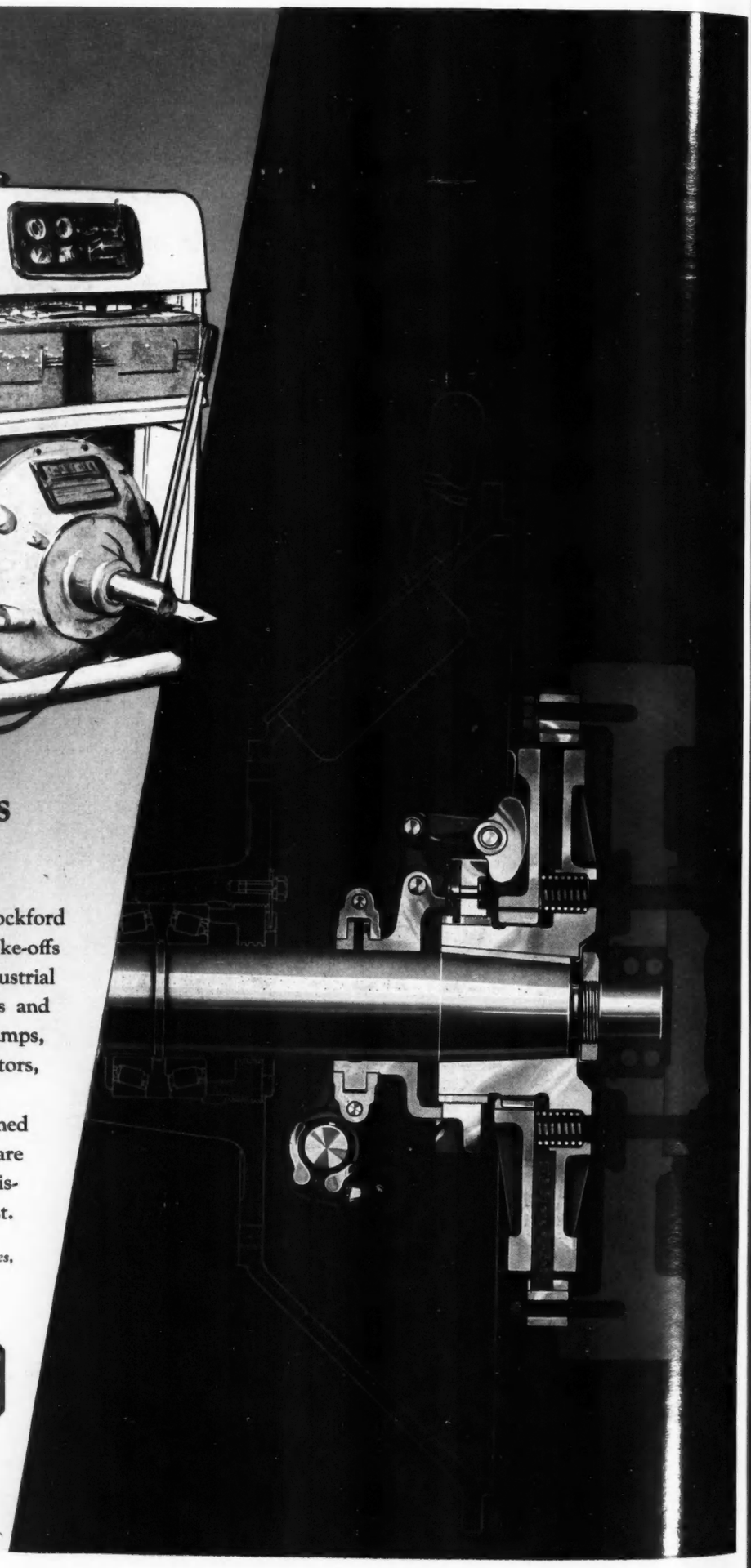

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CRAWLEY FOUNDRY OF A.P.V.-PARAMOUNT LIMITED.

IN 1947, the A.P.V. Company, Limited, founded by Dr. Richard Seligman in 1910 as the Aluminium Plant and Vessel Company, Limited, purchased Paramount Alloys, Limited, of Slough, Buckinghamshire, a company formed in 1945 for the special purpose of producing stainless-steel castings. For five years the parent company operated Paramount Alloys, Limited, as a subsidiary concern but, in June, 1952, it was decided to change the name of this concern to A.P.V.-Paramount, Limited. The A.P.V. Company's aluminium and copper-base alloy foundries were incorporated in the new company and it now operates as an independent subsidiary concern controlling all the foundries of the parent company. A new factory has been built on a 17-acre site at Manor Royal, Crawley, Sussex, and adjoining this is a modern foundry building occupying an area of 64,000 sq. ft., and housing the three above-mentioned founding activities with their personnel. The new foundry building is seen in Fig. 1, on this page, the vertical tubular apparatus on the right is a dust-extraction plant and the separate building partly visible on the right is a boiler-house containing two coal-fired La Mont boilers operating a high-pressure hot-water system for space heating. Together, the A.P.V. buildings at Crawley cover an area of nearly 200,000 sq. ft., and the scheme as a whole forms part of the removal of 1,400 staff and workpeople from the A.P.V. Company's works at Wandsworth Park, London, to the "new town," a process begun this spring and now well advanced. Full advantage has been taken to introduce modern ideas in foundry planning and land is available for expansion.

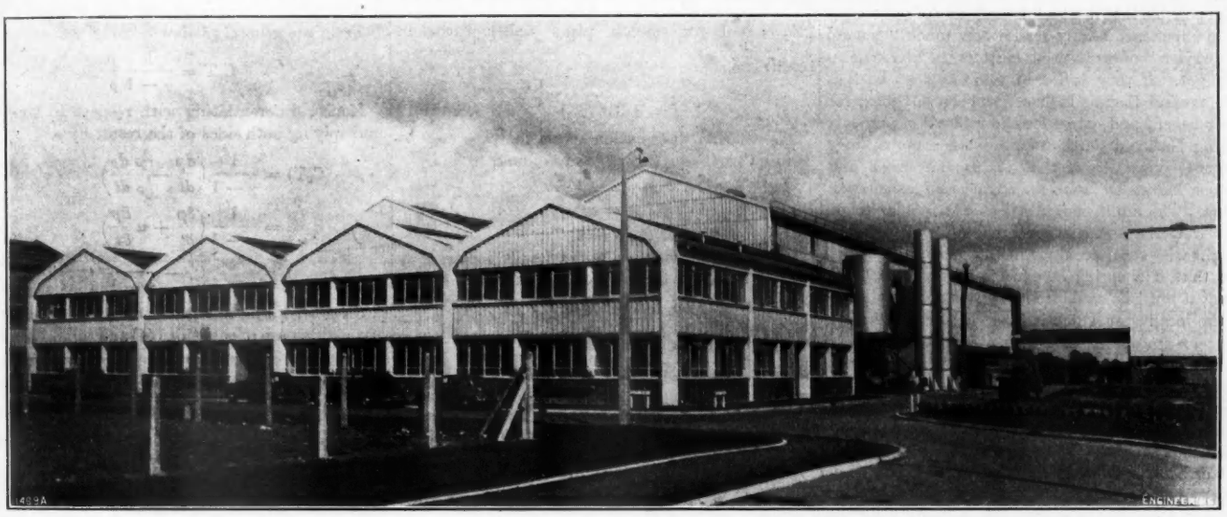


FIG. 1. NEW FOUNDRY AT CRAWLEY, SUSSEX.

On the occasion of a recent "viewing day," we were given the opportunity of visiting the new foundry and the completed portion of the factory, now in full production. The foundry is divided into two autonomous bays, both 60 ft. wide and 250 ft. long, one for stainless-steel castings and the other for aluminium and copper-base alloys. A 20 ft. wide middle bay houses the furnaces and their auxiliary equipment, including the generators. The stainless-steel foundry furnaces are of the electric high-frequency and arc types, while the furnaces in the non-ferrous metal bay are fired by fuel oil. The foundry is not designed for the mass production of any single line of castings, but is laid out to achieve maximum flexibility, and castings of a wide variety of size, shape and quantity can be manufactured. The office block, is on two floors along the front of the foundry, and included on the first floor are the pattern shop and pattern stores.

In the aluminium and copper-base foundry bay, which is usually referred to as the non-ferrous metal foundry, are arranged moulding machines operated by semi-skilled labour, for the continuous production of moulds; moulding sand is fed to each machine from a continuous overhead conveyor. This is seen on the right in Fig. 2, on page 688, which is a view of the non-ferrous metal foundry, taken from the upper stage of the sand-treatment plant. B.T.5 and A.T.2 roll-over moulding machines, supplied and installed by the British Moulding Machine Company, Limited, Faversham, are specially suitable for deep-draw work, and smaller machines supplied by Macnab and Company, Limited, and other firms, are used for the high-speed production of moulds for the smaller castings. Moulds from the machines are closed on a roller conveyor prior to the pouring of the metal. The melting facilities for aluminium and bronze consist of seven Morgan oil-fired furnaces which have an output of about four tons of molten metal a day. Fuel oil for these furnaces is stored overhead and is pre-heated and pumped to the oil nozzles. Low-pressure air is also piped to the fuel nozzles. All pouring pots are pre-heated in underground heaters. As soon as sufficiently cool, the castings are knocked out over grids disposed at the far end of the roller conveyors. The dislodged moulding sand falls through the grids on to rotating tables and is ploughed off on to a continuous underground return conveyor. This feeds it back to the sand-treatment plant. The casting is then taken by pallet and fork-lift truck to the core knock-out and checking area, where it is fettled, inspected and prepared for dispatch.

The stainless-steel foundry, a general view of which is shown in Fig. 3, on page 688, is equipped with four furnace units. An electric-arc furnace supplied by Metalectric Furnaces, Limited, Smethwick, is capable of melting 1½ tons of metal every 90 minutes and is equipped with oxygen blowing apparatus which is used for the control of carbon content. The other three electric melting units comprise Efco-Northrup high-frequency furnaces supplied by the Electric Furnace Company, Limited, and seen on the right in Fig. 3. Their capacities are, respectively, 10 cwt., 5 cwt., and 2 cwt. Each has two furnace-body units fed by the same power equipment and this enables a body to be re-lined when necessary without interrupting production. The combined stainless-steel furnace capacity enables the foundry to produce castings up to a maximum finished weight of 2 tons. The stainless-steel moulding shop contains machine and floor-moulding facilities employing skilled and semi-skilled operatives. Harder ramming is necessary to enable the mould to withstand the stresses involved in stainless-steel casting. In other respects, however, the stainless-steel moulding facilities are similar to those provided in the non-ferrous foundry bay. Stainless steel, owing to its work-hardening characteristics, requires fettling machinery of considerably higher power than is the case with the non-ferrous metals dealt with in the other foundry bay. The heat treatment of various castings is carried out in two furnaces supplied by the Incandescent Heat Company, Limited, of Smethwick, and installed in a separate building.

The sand-treatment and distribution plant supplied by Augusts Limited, Halifax, is an important feature of the new foundry. It runs laterally along the whole width of the building and consists of three separate units, one for the non-ferrous metal bay, one, in the centre, for the core shop, and one for the stainless-steel bay. That seen in Fig. 4, on page 688, is the non-ferrous metal bay sand unit. The plant is under the supervision of one charge-hand and four operators. Sand is stored in large hoppers and, after mixing and milling, is tested for moisture, strength and permeability. It is then distributed along the two overhead conveyor belts into the hoppers feeding the moulding machines in each foundry bay. Control panels regulate the operation of both the underground return conveyors from the knock-outs, the lifting hoppers and the distribution conveyors. An interlock system is provided which automatically stops all motors on the circuit should one of them cease to operate. In the core-sand unit synthetic sands, which are pre-dried in a rotary gas-fired drying machine, are processed. The sand is mixed with binding constituents consisting of oil or molasses and then issued to the adjoining core-making benches. The sand-treatment plant in the stainless-steel bay distributes a mixture of silica sand, bentonite and other constituents but its function is similar to that in the non-ferrous metal bay. The sand plant as a whole is capable of dealing with 170 tons of sand in circuit.

The factory block at Crawley covers 128,800 sq. ft. of space and at present consists of five 457-ft. bays. The machine, press, polishing and fitting shops are well equipped with travelling cranes, and fork-lift trucks are widely employed. A general view of the press shop is shown in Fig. 5, on page 688. The factory and foundry buildings are of welded steel portal-framed construction giving free headroom

with complete absence of cross members. The most noticeable feature of the factory upon first entering it is the bright colouring employed, it being an example of the application of the British Standard colour code for factories. The steelwork is blue, while cranes and all moving parts are painted red. Machinery is painted green and all pipes and mains are in various colours according to their purpose. The roof is of aluminium and glass and all lavatories and cloakrooms are spacious and well fitted.

The architects for the new buildings were Adie, Button and Partners, 29, Weymouth-street, London, W.1; the consulting engineers, W. S. Atkins and Partners, 158, Victoria-street, London, S.W.1; and the building contractors, James Longley and Company, Limited, Crawley.

LITERATURE.

Foundations of Engineering Science.

By LESLIE PILBOROUGH, A.M.I.E.E., A.M.I.E.I. Blackie and Son, Limited, 16-18, William IV-street, Charing Cross, London, W.C.2. [Price 15*s.* net.]

IT is possible that most adult engineers of reasonably wide experience hardly realise how much "general knowledge" of engineering matters they have actually got. If they will read this excellent book it will remind them. It has not been compiled for their benefit and caters for the interest of students taking National Certificate and other preparatory courses—preparatory, that is, to the wider and deeper knowledge that an engineering career will bring. The adult engineer does not require to be told that the ordinary lever balance will measure weight with strict accuracy in any part of the world, but that if a spring balance is to give the same result it must be calibrated in terms of the latitude of the locality at which it is used. He also knows what an isotope is, and that a single helical gear produces an end thrust on the shaft on which it is mounted. A junior at the outset of an engineering career either may be ignorant of these and many other matters or, at the best, may have very hazy ideas about them.

This book deals with the whole range of engineering "fundamentals" with clarity and precision, ranging from the structure of matter to power transmission, structures, combustion, hydrodynamics and the whole field of engineering practice with the exception of electrical plant. Each chapter dealing with any specific branch of work begins with a clear statement of principles. The publishers' claim on the jacket of the book that it contains "all he (the student) will want to know," is an exaggeration. The field covered is so large that the treatment of each matter is necessarily somewhat brief; the chapter, for instance, entitled "Energy" covers 14 pages, including those containing exercises and examination questions. This is not to say, however, that the treatment is anywhere superficial and the book provides a general survey of the whole field of mechanical-engineering practice which will provide the student with the wide background of knowledge which the adult engineer will, in general, have acquired more informally and as a result of varied experience.

LECTURES FOR APPRENTICES.—The Communication Training Centre, a department of the British Association for Commercial and Industrial Education (BACIE), is arranging a series of lectures for apprentices on the importance of clear expression in speech and writing. The first of the series will be delivered at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2, on Wednesday, July 22, commencing at 3 p.m., when Mr. A. C. Leyton, director of the Communication Training Centre, will speak on "Do I Make Myself Clear?" Admission will be by ticket only, obtainable free of charge from the offices of the Centre, 8, Hill-street, London, W.1.

THE EFFECT OF FRICTION ON COMPRESSION AND RAREFACTION WAVES OF FINITE AMPLITUDE.

By F. J. WALLACE, M.Sc., Ph.D., and M. NASSIF, B.Sc., Ph.D.

THE effect of friction in the case of one-dimensional, steady, compressible flow in pipes of circular section has been very exhaustively analysed, particularly by H. Blasius,* and J. Nikuradse.†‡. If the coefficient of friction, f, be defined as

$$f = \frac{dp}{ds}\frac{2d}{\rho u^2} \quad . \quad . \quad . \quad (1)$$

where

$\frac{dp}{ds}$ = pressure gradient

d = pipe diameter

u = mean velocity of flow,

and

ρ = gas density,

the following law, due to Blasius, holds for the relationship between f and Reynolds number $\left(R_e = \frac{ud}{\nu}\right)$ for smooth pipes under turbulent conditions:

$$f = 0{\cdot}316\,(R_e)^{-\frac{1}{4}} \quad . \quad . \quad (2)$$

The velocity distribution across the pipe may be deduced from equation (2) and is found to be:

$$u = cy^{\frac{1}{7}} \quad . \quad . \quad . \quad (3)$$

where y = distance from wall.

For rough pipes, the Blasius law is replaced by the well-known relationships established by Nikuradse,† connecting the coefficient f with Reynolds number and the pipe roughness λ defined as $\lambda = \frac{z}{r}$, where z = mean height of protrusions on pipe wall and r = pipe radius.

When dealing with non-steady flow, the above simple relationships no longer hold. One is therefore confronted with the alternatives of relying entirely on experimental observation, which is unsatisfactory in view of the infinite number of possible wave configurations and the difficulty of correlating large numbers of observed results in the absence of theoretical criteria, or else incorporating the well-known results for steady flow, briefly discussed above, in a theory for non-steady flow.

The latter course has been adopted by E. Jenny,§ whose treatment is based on the theory of characteristics, but the results are given in a form suitable only for incorporation in a step-by-step analysis. It was thought, however, that a different method of approach and presentation, preferably in chart form for rapid extraction of information, would be of value. These charts define the state of the disturbance, i.e., its pressure amplitude and particle velocity, at any time and place. They can be applied to any non-steep wave of finite amplitude. For steep-fronted or shock waves the treatment has to be modified somewhat, and this question also is briefly discussed.

The fundamental equations of one-dimensional flow for an element of unit cross-sectional area and length ds are:

(i) The simplified Navier-Stokes (momentum) equation:

$$\rho\frac{du}{dt} = -\frac{\partial p}{\partial s} + \frac{4}{3}\mu\frac{\partial^2 u}{\partial s^2} - W\rho \quad . \quad (4)$$

where

μ = viscosity

$W\rho$ = frictional drag per unit length per unit area

$$= \frac{u}{|u|}\frac{fu^2}{2d} \quad \text{(see equation 1)}$$

The quotient of the vector and scalar values of the velocity u is introduced in order to define the direction of the frictional drag, i.e., positive for u increasing with s and negative in the reverse case.

(ii) The continuity equation:

$$\frac{\partial\rho}{\partial t} + u\frac{\partial\rho}{\partial s} + \rho\frac{\partial u}{\partial s} = 0 \quad . \quad . \quad (5)$$

(iii) The energy equation, i.e., change in internal energy + change in kinetic energy = work done.

$$\rho\frac{d}{dt}\left(C_v T + \tfrac{1}{2}u^2\right) = -\frac{\partial}{\partial s}(pu) \quad . \quad (6)$$

where C_v = specific heat at constant volume and T = absolute temperature.

Equation (6) implies no addition of external heat. From the general gas law

$$C_v T = \frac{1}{\gamma - 1}\frac{p}{\rho}$$

Hence, differentiating with respect to time and multiplying both sides of the result by ρ,

$$\rho\frac{d}{dt}(C_v T) = \frac{1}{\gamma-1}\left(\frac{dp}{dt} - \frac{p}{\rho}\frac{d\rho}{dt}\right)$$

$$= \frac{1}{\gamma-1}\left(\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial s}\right) - \frac{1}{\gamma-1}\frac{p}{\rho}\left(\frac{\partial\rho}{\partial t} + u\frac{\partial\rho}{\partial s}\right)$$

On substituting this result in the energy equation and making use of equations (4) and (5), equation (6) reduces to

$$\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial s} - \gamma\frac{p}{\rho}\left(\frac{\partial\rho}{\partial t} + u\frac{\partial\rho}{\partial s}\right) + (\gamma-1)\left(\frac{4}{3}\mu u\frac{\partial^2 u}{\partial s^2} - W\rho u\right) = 0 \quad . \quad (7)$$

The presence of the second derivative in equations (4) and (7), renders the solution of the system (4), (5) and (7) very difficult and destroys its hyperbolic character. This term, representing internal, viscous shearing friction is therefore neglected, a step justified by the fact that under turbulent conditions, skin frictional effects, represented by the term W, are of greater magnitude. The modified system of equations therefore reduces to:

$$\left(u\frac{\partial u}{\partial s} + \frac{\partial u}{\partial t}\right) + \frac{1}{\rho}\frac{\partial p}{\partial s} = -\frac{f}{2d}u^2. \quad (8)$$

$$\rho\frac{\partial u}{\partial s} + u\frac{\partial\rho}{\partial s} + \frac{\partial\rho}{\partial t} = 0 \quad . \quad . \quad (9)$$

$$\left(u\frac{\partial p}{\partial s} + \frac{\partial p}{\partial t}\right) - \left(\frac{\gamma p}{\rho}\right)\left(u\frac{\partial\rho}{\partial s} + \frac{\partial\rho}{\partial t}\right) = (\gamma-1)\frac{f}{2d}\rho u^3. \quad (10)$$

These three linear, partial differential equations may be reduced to a system of difference equations by writing—

$$\frac{\partial u}{\partial t} = \frac{u_2 - u}{\Delta t}, \quad \frac{\partial u}{\partial s} = \frac{u - u_1}{\Delta s}, \quad \frac{\partial p}{\partial t} = \frac{p_2 - p}{\Delta t}, \quad \text{etc.,}$$

where the suffixes 1 and 2 refer to the conditions, already known, at two points (s_1, t_1) and (s_2, t_2), the former separated from the position (s, t) by Δs and the latter by Δt.

On substituting in equations (8), (9) and (10), the following system results:

$$u\,[u\Delta t - \Delta s] + p\left[\frac{1}{\rho}\Delta t\right] = -\frac{f}{2d}u^2\Delta s\Delta t + uu_1\Delta t - u_2\,\Delta s + \frac{1}{\rho}p_1\Delta t \quad (11)$$

* "Das Ahnlichkeitsgesetz bei Reibungsvorgangen in Flüssigkeiten." *Forsch. Arb. Ing. Wes.*, vol. 131 (1913).

† "Gesetzmässigkeiten der turbulenten Strömung in glatten Rohren." *Verein Deutscher Ingenieure*, Forsch. Heft 356 (1932).

‡ "Strömungsgesetze in rauhen Rohren." *Ibid.*, Forsch. Heft 361 (1933).

§ "Berechnungen und Modellversuche über Druckwellen grosser Amplitude in Auspuffleitungen." Thesis submitted for Degree of Doktor der Technischen Wissenschaften and published by Amoba-Druck, Basle (1949).

$$u[\rho\,\Delta t] + \rho[u\,\Delta t - \Delta s] = u_1\rho\Delta t + \rho_1 u\Delta t - \rho_2\Delta s \quad (12)$$

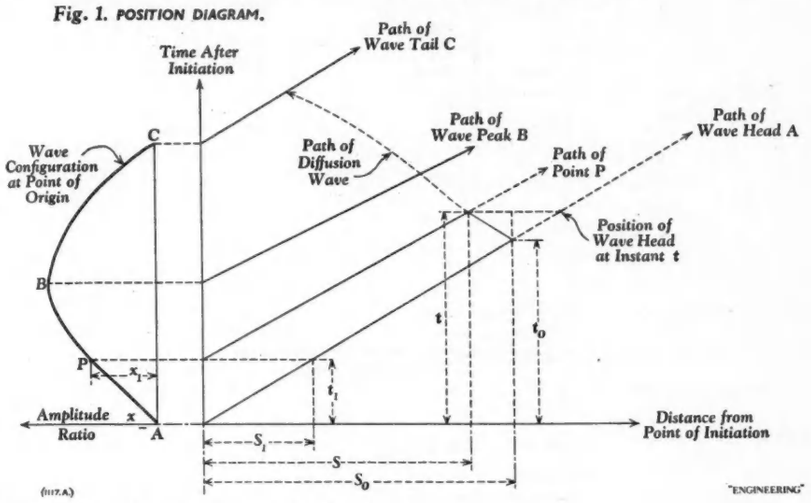
$$p[u\Delta t - \Delta s] - \frac{\gamma p}{\rho}\rho[u\Delta t - \Delta s] = \frac{\gamma-1}{2d}f\rho u^3\Delta s\Delta t + up_1\Delta t - p_2\Delta s - \frac{\gamma p}{\rho}[u\rho_1\Delta t - \rho_2\Delta s] \quad (13)$$

It is now possible to express u, p and ρ in determinental form, such that

$$u = \frac{Z_1}{N},\ p = \frac{Z_2}{N},\ \rho = \frac{Z_3}{N},$$

each of the determinants Z_1, Z_2, Z_3 and N still involving the unknowns u, p, and ρ. However, since solutions for u, p and ρ are possible only along characteristics, certain additional conditions have to be imposed. If the denominator N in the above equations, when equated to zero, has three real roots for $\frac{\Delta s}{\Delta t}$ in terms of u, p and ρ, the system (11), (12), (13) is said to be hyperbolic. The three resulting directions are the directions of the characteristics, along which the solutions of the above system must lie. At the same time, solutions along any one characteristic are indeterminate until defined by the intersection with it of a second characteristic, so that both the numerator and the denominator in the expressions for u, p and ρ must reduce to zero.

Fig. 1. POSITION DIAGRAM.



u may be expressed in determinental form as follows: $u = \frac{Z_1}{N}$, where

$$Z_1 = \begin{vmatrix} -\frac{f}{2d}u^2\Delta s\Delta t + uu_1\Delta t - u_2\Delta s + \frac{1}{\rho}p_1\Delta t, & \frac{1}{\rho}\Delta t, & 0 \\ u_1\rho\Delta t + \rho_1 u\Delta t - \rho_2\Delta s, & 0, & u\Delta t - \Delta s \\ \frac{\gamma-1}{2d}f\rho u^3\Delta s\Delta t + up_1\Delta t - p_2\Delta s - \frac{\gamma p}{\rho}(\rho_1 u\Delta t - \rho_2\Delta s), & u\Delta t - \Delta s, & -\frac{\gamma p}{\rho}(u\Delta t - \Delta s) \end{vmatrix} \quad (14)$$

and $N =$

$$\begin{vmatrix} u\Delta t - \Delta s, & \frac{1}{\rho}\Delta t, & 0 \\ \rho\Delta t, & 0, & u\Delta t - \Delta s \\ 0, & u\Delta t - \Delta s, & -\frac{\gamma p}{\rho}(u\Delta t - \Delta s) \end{vmatrix}$$

From $N = 0$:

$$(u\Delta t - \Delta s)^2 - \frac{1}{\rho}\Delta t\rho\Delta t\frac{\gamma p}{\rho}(u\Delta t - \Delta s) = 0 \quad (15)$$

the three roots of which are:

$$u\Delta t - \Delta s = 0 \quad . \quad . \quad . \quad \text{(i)}$$

$$\frac{\Delta s}{\Delta t} = u \pm \sqrt{\frac{\gamma p}{\rho}} = u \pm a, \quad \text{(ii) and (iii)}$$

(i) being the particle velocity equation, and (ii) and (iii) the propagation velocity equations for rightward and leftward moving waves, respectively.

Writing $u_2 = u_1 + \Delta u$, $p_2 = p_1 + \Delta p$, $\rho_2 = \rho_1 + \Delta\rho$, the determinant Z_1 may now be expressed thus:

$$Z_1 = \begin{vmatrix} -\frac{f}{2d}u^2\Delta s\Delta t + uu_1\Delta t - u_1\Delta s - \Delta u\Delta s + \frac{1}{\rho}p_1\Delta t, & \frac{1}{\rho}\Delta t, & 0 \\ u_1\rho\Delta t + \rho_1 u\Delta t - \rho_1\Delta s - \Delta\rho\Delta s, & 0, & u\Delta t - \Delta s \\ \frac{\gamma-1}{2d}\rho u^3\Delta s\Delta t + up_1\Delta t - p_1\Delta s - \Delta p\Delta s - \frac{\gamma p}{\rho}[\rho_1 u\Delta t - \rho_1\Delta s - \Delta\rho\,\Delta s], & u\Delta t - \Delta s, & -\frac{\gamma p}{\rho}(u\Delta t - \Delta s) \end{vmatrix}$$

Subtracting column II multiplied by p_1 and column III multiplied by ρ_1 from column I, and bearing in mind that $N = 0$,

$$\frac{Z_1}{\Delta s} = \begin{vmatrix} -\frac{f}{2d}u^2\Delta t - \Delta u, & \frac{1}{\rho}\Delta t, & 0 \\ -\Delta\rho, & 0, & (u\Delta t - \Delta s) \\ \frac{(\gamma-1)}{2d}f\rho u^3\Delta t - \Delta p + \frac{\gamma p}{\rho}\Delta\rho, & u\Delta t - \Delta s, & -\frac{\gamma p}{\rho}(u\Delta t - \Delta s) \end{vmatrix}$$

Putting $Z_1 = 0$,

$$\left(\frac{fu^2}{2d}\Delta t + \Delta u\right)(u\Delta t - \Delta s)^2 - \frac{\Delta t}{\rho}(u\Delta t - \Delta s)\times\left[\frac{\gamma p}{\rho}\Delta\rho - \frac{\gamma-1}{2d}f\rho u^3\Delta t + \Delta p - \frac{\gamma p}{\rho}\Delta\rho\right] = 0 \quad . \quad . \quad (16)$$

Substituting for $u\,\Delta t - \Delta s = \pm a\,\Delta t$ from (ii) and (iii), above

$$\Delta u = \mp\frac{\Delta p}{a\rho} - \frac{f}{2d}u^2\left[1 \mp (\gamma-1)\frac{u}{a}\right]\Delta t \quad (17)$$

Changes in state may be considered isentropic without introducing appreciable errors. Bearing this in mind, and re-introducing differentials in place of the finite differences, equation (17) may be rewritten:

$$du = \mp\frac{2}{\gamma-1}da - \frac{f}{2a}\frac{u}{|u|}u^2 \times\left[1 \mp (\gamma-1)\frac{u}{a}\right]dt \quad (18)$$

the top sign referring to rightward- and the bottom sign to leftward-moving wave points, respectively, and the equation as a whole representing the changes in the particle and acoustic velocities associated with a wave point moving from position (s, t) to position $(s + ds, t + dt)$.

Equation (18) may now be applied to establish expressions for changes in particle velocity and pressure amplitude for finite increments of time and distance. A B C, in Fig. 1, herewith, represents the wave profile (i.e. the time-amplitude relationship) under frictionless conditions at the point of origin of the wave. This wave is subsequently propagated rightwards into a pipe of considerable length, the propagation paths of successive points on the wave being indicated in the diagram. In an ideal, frictionless fluid, every point on the original wave profile A B C retains its initial amplitude. In the presence of friction, however, two effects occur simultaneously:

(i) Each wave point is attenuated, i.e. its amplitude decreases.

(ii) The resistance encountered by any wave point in the course of its propagation along the pipe is "reported back" to points in the rear of the wave. Thus a succession of small "diffusion" waves is continuously proceeding in opposition to the main wave towards the wave tail, thereby increasing the pressure-amplitude at the rear of the wave.

Clearly, the two effects discussed above tend, to some extent, to cancel each other in respect of pressure-amplitude, while in the case of particle-velocity the two effects are additive and tend towards a progressive reduction of kinetic energy which reappears in the form of frictional reheat. Furthermore, diffusion effects are most pronounced at the rear of the wave, while attenuation is most marked at the wave head, which has travelled the longest distance from the point of origin.

Referring back to equation (18), it is most convenient to write the term

$$\mp\frac{2}{\gamma-1}da \quad \text{as} \quad \mp\frac{2}{\gamma-1}a_o d\left(\frac{P}{P_o}\right)^{\frac{\gamma-1}{2\gamma}}$$

where a_o and P_o refer respectively to the acoustic velocity and pressure of the undisturbed air, and P to the absolute pressure of the particular wave point under consideration.

In order to simplify the form of the equations in the following analysis, it is proposed to introduce the symbol x for the amplitude ratio, i.e.

$$x = \left(\frac{P}{P_o}\right)^{\frac{\gamma-1}{2\gamma}} = \left(\frac{P}{P_o}\right)^{\frac{1}{7}} \quad \text{for air.}$$

Equation (18) may now be rewritten:

$$du = \mp 5a_o dx - \frac{f}{2d}\frac{u}{|u|}u^2\left[1 \mp \frac{2}{5}\frac{u}{a}\right]dt \quad (19)$$

Considering now a wavepoint P of initial amplitude-ratio x and at a distance s from the origin (see Fig. 1), where the amplitude ratio is taken as

$$x' = x + A' \quad . \quad . \quad . \quad . \quad . \quad (20)$$

(A' being a small quantity of unspecified sign) and substituting as a legitimate approximation the expression for particle velocity for frictionless waves,* i.e.

$$u = 5a_o(x - 1), \quad . \quad . \quad (21)$$

equation (19), applied to a wave point moving to the right, becomes:

* Bannister and Mucklow. "Wave Action following Sudden Release of Compressed Air from a Cylinder." *Proc. I. Mech. E.*, vol. 159, page 264 (1948).

EFFECT OF FRICTION ON COMPRESSION AND RAREFACTION WAVES.

Fig. 2. PRESSURE RATIO CORRECTION. COMPRESSION WAVES.

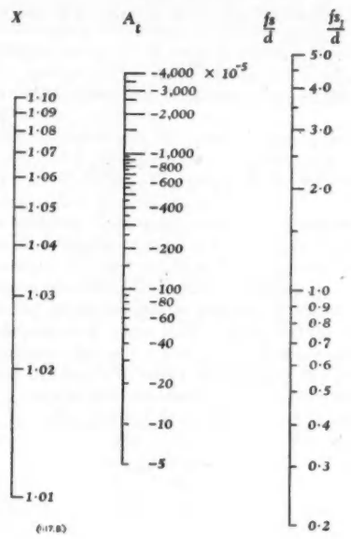


Fig. 3. PRESSURE RATIO CORRECTION. RAREFACTION WAVES.

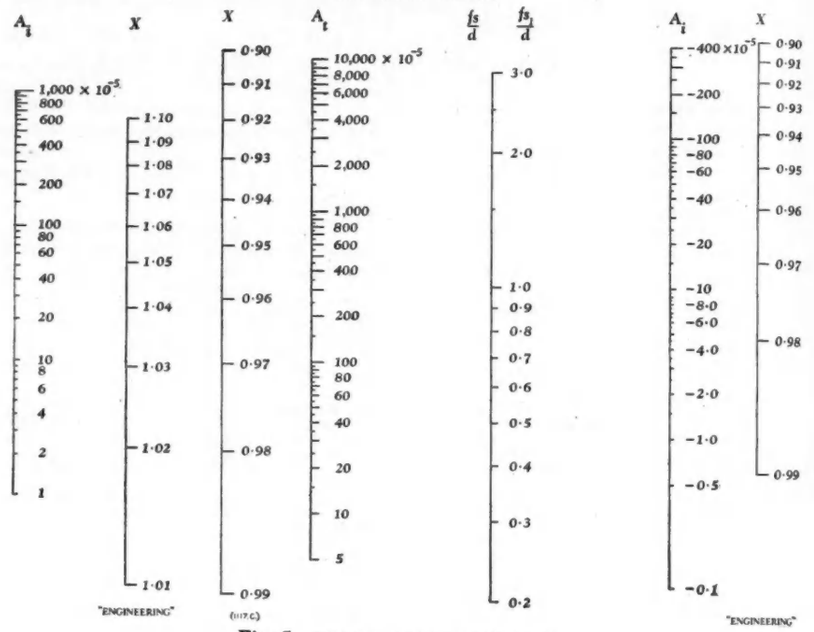


Fig. 4. PARTICLE VELOCITY CORRECTION. COMPRESSION WAVES.

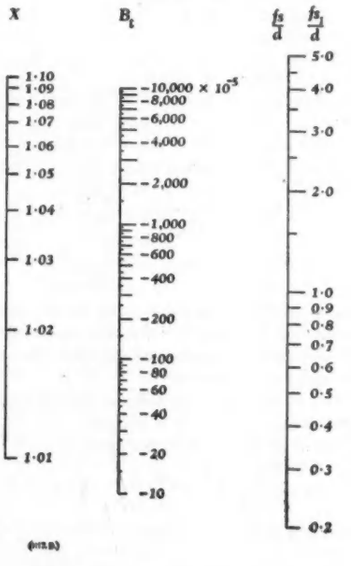
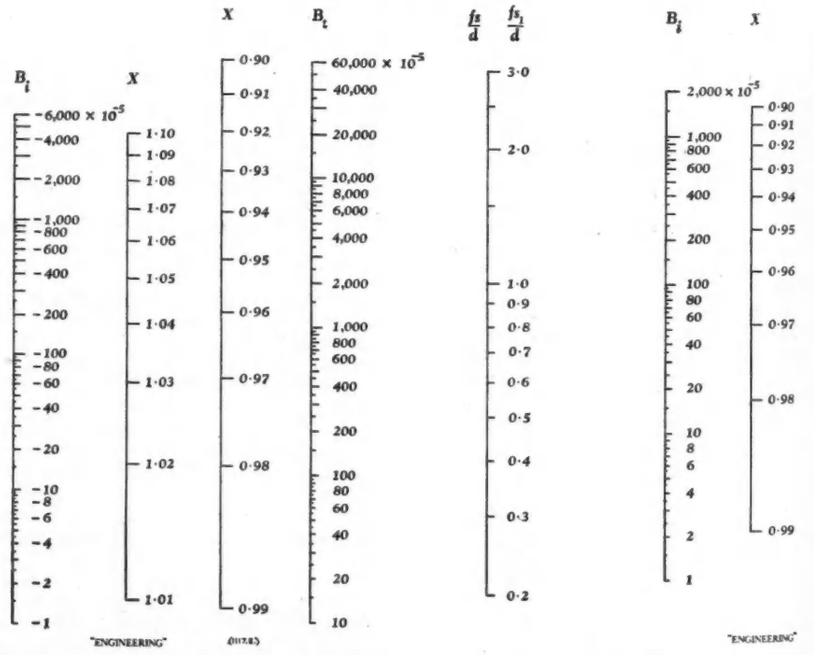


Fig. 5. PARTICLE VELOCITY CORRECTION. RAREFACTION WAVES.



$$du = -5a_o(x' - x) - \frac{f}{2d}[5a_o(x-1)]^2 \times \left[1 - \frac{2}{5}\frac{5a_o(x-1)}{a_o x}\right](t - t_1)$$
$$= u' - 5a_o(x-1)$$

or

$$u' = -5a_o(1 - x + A') - \frac{f}{2d}[5a_o(x-1)]^2 \times \left[1 - \frac{2}{5}\frac{5a_o(x-1)}{a_o x}\right](t - t_1) \quad . \quad (22)$$

where t and t_1 are respectively the time when point P reaches position s and its time of formation, both measured from the instant of release of the wave-head A, and u' refers to the changed particle-velocity at distance s.

Equation (19) is now applied to the leftward-moving diffusion wave which meets the point P at time t and distance s from the origin (see Fig. 1). This diffusion wave proceeds from the wave head and travels over the entire wave A B C in the manner shown. It commences its journey at some unspecified time t_o and reaches P at time t, the length of the interval thus being $(t - t_o)$. The time t_o is found as follows:

The distance of the wave head A from the point of origin at the instant t_o is given by $s_o = a_o t_o$.

The mean velocity of propagation of the diffusion wave between t_o and t may be written:

$$c_{av} = \frac{1}{2}(a_o + a_o x' - u'), \quad \text{so that}$$

$$t - t_o = \frac{2(a_o t_o - s)}{a_o + a_o x' - u'} \quad . \quad (23)$$

whilst

$$t - t_1 = \frac{s}{a_o(6x-5)}, \quad . \quad (24)$$

where $a_o\ (6x - 5)$ is the propagation velocity of point P, assumed to be constant and equal to that for the frictionless case.*

On replacing u' and x' by their approximations $u = 5a_o\ (x - 1)$ (equation 21), and x, equation (23) becomes

$$t - t_o = \frac{2(a_o t_o - s)}{2(3 - 2x)a_o} = \frac{t_o - \frac{s}{a_o}}{(3 - 2x)};$$

* Bannister and Mucklow, *loc. cit.*

whence

$$t_o = \frac{(3-2x)t + \frac{s}{a_o}}{2(2-x)} \quad . \quad . \quad (25)$$

and

$$t - t_o = \left[\frac{(3-2x)t + \frac{s}{a_o}}{2(2-x)} - \frac{s}{a_o}\right] \Big/ (3-2x)$$

$$= \frac{t_1 + \frac{s}{a_o(6x-5)} - \frac{s}{a_o}}{2(2-x)} \quad . \quad (26)$$

Substituting now, in equation (19), the relations for the leftward-moving diffusion wave and taking the mean particle-velocity between t_o and t as $\frac{1}{2}[5a_o(x-1)]$, the equation becomes

$$u' = 5a_o(x - 1 + A') - \frac{f}{2d}\left[5a_o\frac{(x-1)}{2}\right]^2 \times \left[1 + \frac{2}{5}\frac{5a_o(x-1)}{a_o(x+1)}\right](t - t_o) \quad . \quad (27)$$

On inserting the value of $(t - t_o)$, from equation (26), in (27) and of $(t - t_1)$ from equation (24), in (22), and finally equating (22) and (27), the following expression for A′ results:

$$A' = -\frac{5fs}{8d}\frac{(x-1)^2}{6x-5}\left[\frac{2(2-x)}{x} + \frac{3(3x-1)(x-1)}{2(2-x)(x+1)}\right] + \frac{5fs_1}{32d}\left[\frac{(x-1)^2(3x-1)}{(2-x)(x+1)}\right] \quad . \quad . \quad (28)$$

where $s_1 = a_o t_1$, i.e., the distance of the wave head from the origin at the instant of formation of P.

It may easily be shown that for a rarefaction wave the expression for A′ is identical with (28), except that the right-hand side has the opposite sign. The actual pressure ratio at time t is, of course, obtained by inserting the value of A′ from (28) in (20), and raising x' to the seventh power.

As mentioned previously, the above method applies only to waves which are not steep. For flat-topped, steep-fronted waves, as discussed by Bannister and Mucklow,* the modified expression for A′ becomes:

$$A'_s = -\frac{5fs}{4d}\frac{(x-1)^2}{(6x-5)} \times \left[\frac{(2-x)}{x} - \frac{(3x-2)}{x}\frac{\sqrt{\frac{6x^7+1}{7}} - (6x-5)}{5 - 4x + \sqrt{\left(\frac{(6x^7+1}{7}\right)}}\right] \mp \frac{5fs_1}{4d}\frac{\sqrt{\frac{6x^7+1}{7}}(3x-2)(x-1)^2}{(5-4x) + \sqrt{\left(\frac{6x^7+1}{7}\right)}} \quad . \quad (28a)$$

For compression waves, the first term on the right-hand side of (28) is always negative and proportional to the distance travelled by the wave point under consideration. It may therefore be regarded as the "attenuation" term and is denoted by A_t. The second term which, for a compression wave, is always positive and proportional to the distance travelled by the wave head A up to the instant of formation of point P, may be regarded as the "diffusion term" and is denoted by A_i. Similar remarks apply to rarefaction waves, the signs of A_t and A_i, however, being reversed.

The appropriate correction term for the particle-velocity u may be obtained by substituting the value of A′ above in (22). This gives

$$\frac{u' - u}{a_o} = B' = \mp\frac{25fs}{8d}\frac{(x-1)^2}{(6x-5)} \times \left[\frac{2(2-x)}{x} - \frac{3(3x-1)(x-1)}{2(2-x)(1+x)}\right] \mp \frac{25fs_1}{32d}\left[\frac{(x-1)^2(3x-1)}{(2-x)(1+x)}\right] \quad . \quad . \quad (29)$$

the top sign referring to compression, and the bottom sign to rarefaction waves.

The first term, which may be denoted by B_t, may again be regarded as the "attenuation term," and the second, denoted B_i, as the "diffusion term." Both terms are of the same sign, showing that the effects of diffusion and attenuation on particle velocity are additive. In discussing the term A′ for the pressure amplitude correction, the two effects were found partly to cancel each other. Both these results are in agreement with the general remarks made previously about attenuation and diffusion.

The designations "attenuation term" and "diffusion term" must be regarded as being general, the former being strictly correct only when $s = 0$, i.e., at the point of origin, and the latter only at the wave head.

The true attenuation term may be written:

$$A_t' = \mp\frac{5fs}{8d}\left[\frac{(x-1)^2}{(6x-5)}\frac{2(2-x)}{x}\right],$$

whilst the true diffusion term becomes:

$$A_i' = \pm\frac{5fs_1}{32d}\left[\frac{(x-1)^2(3x-1)}{(2-x)(x+1)}\right] \mp \frac{15fs}{16d}\frac{(x-1)^2(3x-1)}{(2-x)(x+1)(6x-5)}.$$

For purposes of numerical evaluation, the results are given in nomogram form in Figs. 2, 3, 4 and 5.

To facilitate the interpretation of the results, the quantities A′, x, $\frac{fs}{d}$, $\frac{fs_1}{d}$, for the pressure-ratio correction, and B′, x, $\frac{fs}{d}$, $\frac{fs_1}{d}$, for the particle-velocity correction, have been plotted in the form of "carpet diagrams,"* each carpet applying to one of the following values of x: 0·95, 0·98, 1·0, 1·01, 1·04, 1·07, 1·10. The corresponding pressure-ratios are 0·702, 0·870, 1·0, 1·072, 1·316, 1·606, 1·949, equivalent to a range of gauge pressures, at 14·7 lb. per square inch atmospheric pressure, from −4·38 lb. per square inch to 13·95 lb. per square inch. The range covered by the charts should be more than adequate, since pressure ratios in pipe systems of internal-combustion engines hardly ever reach the extremes indicated above. The value 3 for the quantities $\frac{fs}{d}$ and $\frac{fs_1}{d}$ corresponds to a pipe length of 37·5 ft. in the case of a pipe of 3 in. diameter in which $f = 0{\cdot}02$, a usual value.

A number of interesting conclusions may be drawn from the carpet diagrams: For the same gauge pressure, rarefaction waves suffer much more rapid attenuation than compression waves. This agrees fully with observation, and has an adverse effect on the scavenging potentialities of rarefaction waves in tuned two-stroke engines. Owing to the very rapid reduction in particle-velocity, the mass of burnt gases swept out of the exhaust-pipe system under actual conditions is considerably less than the figure arrived at on the basis of calculations neglecting friction. Comparison between the "carpets" for pressure-ratio and particle-velocity correction shows the additive effect of attenuation and diffusion on particle-velocity, and the partial cancellation of the two effects in the case of pressure ratio. Values of the attenuation corrections A′ and B′ for values of $\frac{fs}{d}$, $\frac{fs_1}{d}$ and x intermediate to the plotted lines are, of course, obtained by interpolation.

(To be continued.)

* *Ibid.*

* A. H. Yates, "Carpets and Lattices." *Aircraft Engineering*, vol. 18, page 8, (1946).

THE INSTITUTION OF NAVAL ARCHITECTS.

(Continued from page 649.)

THE proceedings at the technical session on Friday morning, March 27, during the Spring Meeting in London of the Institution of Naval Architects, opened with the presentation of a paper by Mr. W. C. S. Wigley, M.A., on "Water Forces on Submerged Bodies in Motion." The chair was taken again by Sir Charles S. Lillicrap, K.C.B. A summary of the paper is given below.

WATER FORCES ON SUBMERGED BODIES IN MOTION.

The purpose of the paper, the author stated, was to state the present position of knowledge of possible methods of calculating the forces and moments acting on a body in motion in a fluid in the neighbourhood of a free surface. In a perfect fluid of infinite extent, a moving body would experience no force, but only a couple tending to turn its motion into the direction of the axis of least inertia. In a viscous fluid, there would be also a frictional force opposing the motion; and, if the body were not symmetrical, there would be a circulation round it, producing a force normal to the direction of motion. In the neighbourhood of a horizontal free surface, there would be an additional vertical force and moment, and, if the body were not symmetrical, a horizontal moment also, due to the presence of the free surface. Actually, there would be interaction between the forces caused by viscosity and those which would exist in a perfect fluid, but, to obtain a first approximation to a determination of the forces, such interferences were neglected; i.e., the assumption was made that a body with a horizontal axis of symmetry, moving in the direction of that axis, would be subject to a resistance composed of the sum of the frictional resistance and the wave resistance due to the free surface, and to a vertical force and couple due only to the free surface. The method of solving the problem mathematically was then described, with particulars of the assumptions made, though the actual mathematical expressions were not given in the paper.

As typical of the application of the method, numerical results were given for a submerged spheroid, showing that its wave resistance varied with the Froude number as in the case of a floating body. The absolute value of the wave resistance decreased with increased immersion until, at an immersion equal to half the length, it was not more than 3 per cent. of the frictional resistance. The vertical force began as an upward force at low speeds, with a coefficient equal to that for the case of a fixed surface instead of a free surface. The coefficient increased with speed up to a Froude number of 0·45, after which it fell rapidly, becoming negative at a Froude number of about 0·6 and reaching its greatest negative value at a Froude number of about 1·4. Thereafter it increased, though remaining negative. The moment started with a zero value of the coefficient at Froude numbers below 0·15, and was small up to a Froude number of about 0·35, while oscillating between positive and negative. Above a Froude number of 0·35 it was always negative (i.e., tending to depress the bow), reaching its greatest negative value at a Froude number of about 0·55. The paper concluded with a general consideration of the application of the method to other cases of motion.

DISCUSSION.

The first speaker was Sir Thomas H. Havelock, who said that it was very valuable to have such a clear statement of the problem of submerged bodies in motion, together with such a comprehensive set of calculated results. Although other methods might be used, the work was much simplified by the use of fictitious forces between sources and sinks. He suggested that some references to general theory might be useful to the reader; for instance, a paper by Kotchin (Moscow Conference on Wave Resistance, 1937) and a recent general study by Cummins (*T.M.B. Report, No.* 780, Washington, 1952). Not every solid of revolution could be represented by a line distribution, though many

could be, either exactly or approximately. For the general ellipsoid, the known distribution was on a certain plane, and he thought that the corresponding forces could be calculated without much more difficulty. In Fig. 2, showing the coefficient of vertical force for a submerged spheroid, the vertical force changed from positive to negative with increasing speed, as explained in the paper. It could easily be seen, by picturing the streamlines in the two limiting cases, that, for a very low speed, the body would be attracted towards the surface, and that, for a very high speed, there would be apparent repulsion. The two limiting cases could be worked out independently, the vertical force coefficient having equal numerical values, positive or negative. However, in passing from one extreme to the other, the coefficient rose to a maximum and then fell to a minimum. That was characteristic of many ship problems for which the solution had been obtained using the complete linear equation for the condition at the water surface. Considering, for instance, the coefficient of virtual inertia for the heaving motion of a floating solid, and its variation with the frequency of the motion: the graph started from the limiting value for a rigid water surface, rose to a maximum and then fell to a minimum before eventually approaching the limiting free surface value for high frequencies.

With the method used for approximating to the velocity potential, first-order terms for the horizontal and vertical forces were given entirely by the first approximation, but first-order terms for the moment were contributed also by the second approximation to the velocity potential; therefore, he criticised the wording in the paper which referred to "the second approximation to the moment." The term referred to was an essential part of the first approximation to the moment, though it happened to come from the second approximation to the velocity potential on account of the method used in obtaining that function. He would like to see real second approximations both for the forces and for the moment; but there were many important problems which still lacked even a first approximation.

Dr. R. S. Guilloton said that, as Mr. Wigley's work was very general, he had examined a spheroid to see how the problem would appear in a particular case. The functions used were those published in his own paper on the potential theory of wave resistance (*S.N.A.M.E.*, New York, 1951); they were divided into oscillating functions which had the resistance, and non-oscillating functions which, added to the oscillating functions, gave the pressure in the fluid. Although Mr. Wigley's calculations were more rigorous than his own, their values of the coefficient of wave resistance agreed closely. The calculations were repeated with the body divided by three water lines. The surface wave was calculated by those means and the resistance was calculated from the surface wave. The resistance thus found differed by only 6 per cent. from that calculated directly. The resistance was then calculated with the spheroid in its position of natural trim, and the same value was found as in the horizontal position. There was a difference of 11 per cent. in the vertical force coefficients calculated by Mr. Wigley and by himself, but that was due to the fact that Mr. Wigley's calculations were for a fine spheroid. His own value of the coefficient of moment was about 3·3 times that of Mr. Wigley, owing to the fact that the methods of approximation were not identical. To compare the results of calculations with experiment, "form resistance" must be considered, and that could not be calculated without the knowledge of wake distribution.

Professor Kenneth S. M. Davidson, of the Stevens Institute of Technology, said that, in America, they were interested in the problem, and had been impressed with the fact, that without some sort of theoretical guidance, it became extremely difficult to produce results by experiment alone. The shape of the curves given in the paper made it evident that, if data were obtained which corresponded to those curves, without some reason to suppose that they might be right, there was a strong inclination to suppose that they might be wrong. It was rather a pity that experimental results were not given with the theory; it would add to the value of the work if both were given in the one paper.

Sir Geoffrey Taylor commented that one of the suggestions made in the paper was that the methods indicated might be applied to something which had different dimensions vertically and horizontally. It would seem that integrating all over a flat surface would be very difficult; but was it possible, instead of having a line of sources, to have only a line source with associated quadruples? That would give a surface which was different in width and height, and might make the integrals easier. Obviously, the same difficulties would be multiplied many times; but that might be easier than trying to integrate over the surface.

Mr. John Hall thought that the value of the paper would be increased considerably if it gave a little more indication of the actual mathematics involved. Mr. Wigley proceeded very easily from the second to the third approximation, but for others it might not be quite so easy as he found it. He asked Mr. Wigley to amplify the statement that the third approximation was necessary to find the moment. He stated that the value of the potential sufficed for the calculation of the forces, though not for that of the moment, which appeared to imply that it is only a matter of approximation. A little later he said that a contribution to the moment was obtained from the second approximation, and implied that, as a matter of principle, there must be a third approximation.

Mr. G. H. Room said that the paper represented a great contribution to practical hydrodynamic theory. Similar calculations, of moments at any rate, had been carried out by Dr. Hartley Pond, at the Taylor Model Basin in the United States, and he had obtained figures for the Rankine ovoid, instead of a spheroid, which showed close agreement with figures worked out by Mr. Wigley for the same body. The special functions mentioned in the paper, which led to a better approximation to the actual figures in the table, had been worked out more accurately since the figures given were prepared. The variation was quite small. Those functions could be used for other bodies, using the integrals in the mathematical theory, and they were being so used to provide similar calculations for less symmetrical bodies, still bodies of revolution, but unsymmetrical fore and aft.

Mr. J. R. Shearer congratulated Mr. Wigley on having extended the field from the single force, i.e., the resistance, to the consideration of all the forces and moments. It was rather a temptation to extend the work to the calculation of trimming moment on the surface of the body; presumably, when that problem was brought in, the difficulties of attaining approximation to the condition of free surface would be much more difficult. A practical use of that kind of work would be in connection with the consideration of the stability of a submarine body. In such a case, as far as it went, the body would be constrained to move along its axis. If the body were free, he supposed that it would be moved by the forces and moments which Mr. Wigley had calculated. In the only experience they had had at the National Physical Laboratory, within his own recollection, of towing submarine bodies in revolution, great difficulty was encountered in towing near the surface, particularly when the wind was appreciable and the bodies became unstable. He asked whether Mr. Wigley could say anything about that.

Mr. Lloyd Woollard said that, apparently, from the diagrams, the forces and moments varied as the fourth power of the beam, though that was not explicitly stated. Would Mr. Wigley confirm it or otherwise? Secondly, a previous speaker had said that he would like to see some of the mathematical formulæ on which the calculations were based. They were given, of course, in the papers by Sir Thomas Havelock, which Mr. Wigley had cited; nevertheless, he was not certain that the last two references were easily accessible, and he suggested that, if Mr. Wigley could add an appendix containing a formula or two, it would be helpful.

Mr. Wigley, replying to the discussion, said that he could not reply immediately to all the technical questions raised. Reference had been made, however, by several speakers, to the use of the expression "first approximation" for the calculation of the moment without the introduction of the correction term. He thought that the criticism was justified, and he would alter the wording slightly. What he had called a "first approximation" was not a physical thing; it was just one term in mathematics, and isolated, he supposed, quite arbitrarily. In the same way, when Dr. Guilloton was calculating by a different method, his method was not quite good enough to calculate to the moment accurately, although it was much better than what the paper termed the first approximation. He did not expect Dr. Guilloton's first approximation to agree with his own, because, when both methods arrived at the truth, they must agree; but when both gave incorrect approximations there was no reason why they should agree at all.

(To be continued.)

FOURTH ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

THE following papers will be presented at the fourth Anglo-American Aeronautical Conference, which is to be held in London from September 15 to 17: "The Control of Flight," by Mr. Preston R. Bassett; "Structure for High Speed Aircraft," by Mr. Hall L. Hibbard; "Some Observations on the Problem of Fatigue of Airplane Structures," by Mr. R. V. Rhode; "Some Factors Affecting Helicopter Design and Future Operations," by Professor R. H. Miller; "Pod Mounting of Turbo-Jet Engines," by Mr. George S. Schairer; "Boundary Layer Control," by Mr. Courtland D. Perkins; "Structural Adhesives for Metal Aircraft," by Dr. N. A. de Bruyne; "The Thermal De-Icing of Aircraft," by Mr. J. L. Orr; "The Introduction of the Comet into Service," by Mr. A. C. Campbell-Orde, C.B.E.; "The Aerodynamics of Compressor Blade Vibration," by Mr. H. Pearson; "Power Plants for Helicopters," by Captain A. Graham Forsyth; "The Development of a Family of Delta Aircraft," by Mr. S. D. Davies; and "Basic Prerequisites Essential to Production," by Mr. K. A. Neale. Before the conference opens, delegates will be able to attend the Wilbur Wright Memorial Lecture, to be given on September 14 by Professor N. J. Hoff on "Structures," after which a reception will be held at the headquarters of the Royal Aeronautical Society, 4, Hamilton-place, London, W.1. The Conference is open to members of the Institute of Aeronautical Sciences and to members of the Royal Aeronautical Society.

POWDER METALLURGY EXHIBITION.—An exhibition of some hundreds of machine components, produced by means of powder metallurgy, is being arranged by Powder Metallurgy, Ltd., 59-62, High Holborn, London, W.C.1, and will be held at the offices of the firm's parent company, F. W. Berk & Co., Ltd., Commonwealth House, 1-19, New Oxford-street, London, W.C.1, from Monday, June 8, to Wednesday, June 10, inclusive. The collection of sintered parts on view is being contributed by more than 30 firms and will be representative of modern British, American and European achievements in this field. The exhibition will be open from 10 a.m. to 5 p.m. each day.

SUMMER SCHOOL AND CONFERENCE ON THE PLASTIC DEFORMATION OF METALS.—A conference and course of lectures, intended mainly for university research students and members of the staffs of Government and industrial laboratories, have been arranged by the H. H. Wills Physical Laboratory of the University of Bristol, in co-operation with the Institute of Physics, on "The Theory of the Plastic Deformation of Metals, with Special Reference to Creep and Fatigue." Both functions will be held at the Wills Laboratory; the school on Monday and Tuesday, July 13 and 14, and the conference on Wednesday and Thursday, July 15 and 16. At the school, lectures by the staff of the Wills Laboratory will be given on "Properties of Edge and Screw Dislocations and Evidence for Their Existence," "Evidence for the Motion of Single Dislocations," "The Frank-Read Source and the Origin of Slip Lines; and the Origin of Work-Hardening," "Kinking and Twinning," and "Thermal Recovery; Transient and Steady-State Creep." The school will close with a discussion on creep. On July 15, there will be morning and afternoon sessions on plastic deformation and creep in metals, and, on July 16, there will be morning and afternoon sessions on the fatigue and fracture of metals. Applications should be sent to the Director, Department of Adult Education, The University, Bristol, 8, as soon as possible.

POWER JETS' GAS-TURBINE PATENTS.

Fig. 1.

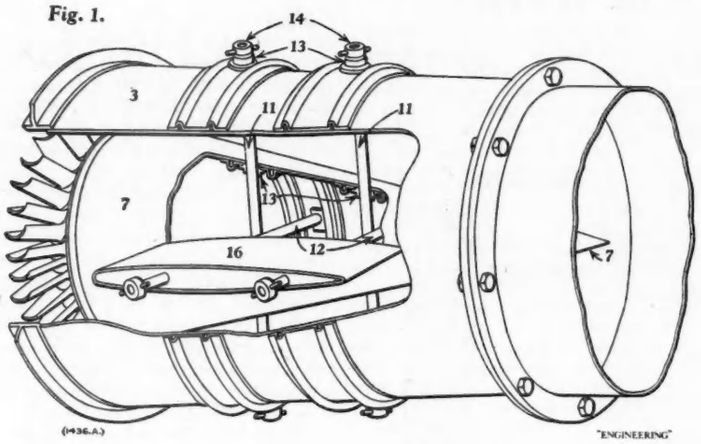


Fig. 3.

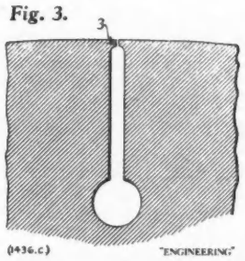


Fig. 4.

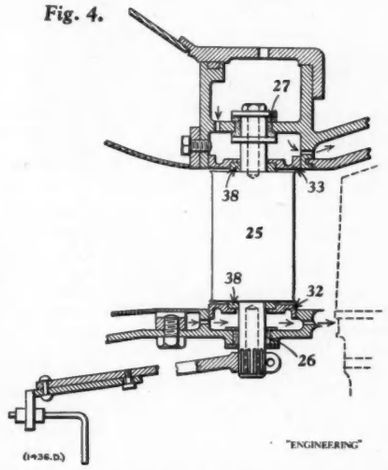


Fig. 2.(a)

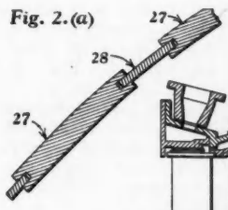
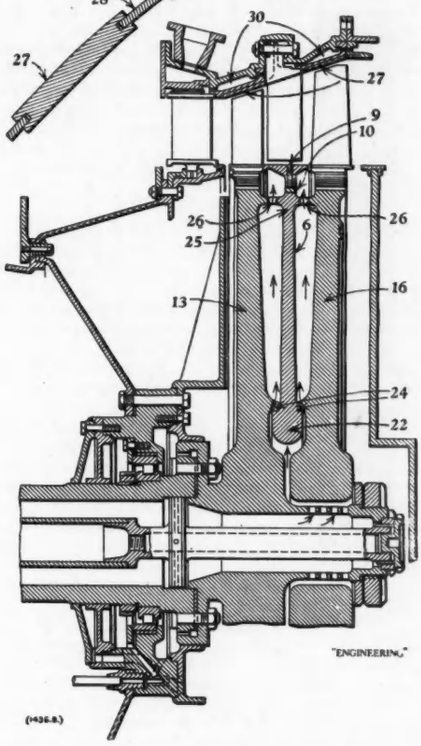


Fig. 2.



POWER JETS' GAS-TURBINE PATENTS.—VII.*

TURBINES.

SINCE any comprehensive patent holding is naturally concerned to a large extent with features of construction, it is inevitable that lists of patents relating respectively to such structurally similar objects as axial-flow compressors and turbines must overlap to some extent. Thus, several Power Jets' patents covering inventions which have a substantially equal applicability to turbines have already been reviewed in Part V devoted to compressors; Patents Nos. 610,314, 606,151, 632,923, 587,518, 611,405 and 646,728 may be mentioned as examples. The present section is divided into two sub-sections, patents relating to inward-flow (or centripetal) turbines being separated from those relating to axial-flow turbines.

Axial-Flow Turbines.—For the sixth and last time, chronology places a Whittle patent at the head of the list. This patent, No. 582,978, is drawn to an invention which has been widely adopted in the aero-engine field to support the fairing, or "tail cone," which is commonly provided downstream of a turbine; such a member requires to be mounted so that it can withstand high fluid velocities and temperatures, while the setting up of undue stresses and resistance to the exhaust flow is avoided as far as possible. As shown by Fig. 1, the fairing 7 is supported by struts 11 and 12 of which the axes radiate in intersecting directions from the turbine axis; the struts are free to slide in bushes 13 carried by the fairing and by the exhaust pipe 3 and are held in place by external collars 14. The collars, which are conveniently locked on the struts by means of split pins, are spaced apart sufficiently to allow for thermal expansion of the individual parts in the radial sense, the parts being otherwise positively located in the desired relation. The portions of the struts which span the annular exhaust passage are preferably enclosed in streamlined sheet-metal fairings, as indicated at 16 in the case of the horizontally-arranged struts.

* Part VI appeared on page 644, *ante*.

A difficulty often confronting the turbine designer is the prevention of blade rubs on shut-down, due to cooling and consequent contraction of a relatively light stator structure at a more rapid rate than that of the rotor; any attempt to avoid rubbing by resort to the use of excessive tip clearance must, of course, result in loss of efficiency. Conversely, efficiency may be lost, during any warming-up period, due to excessive tip clearance resulting from relatively tardy expansion of a relatively heavy rotor. The invention forming the subject of patent No. 597,165 is directed to a solution of these problems. In the construction illustrated by Fig. 2, the rigid stator structure is shielded from the hot gas stream by shrouding which presents a peripherally continuous surface under all operating conditions and is supported in fixed radial relation to the stator assembly proper but with freedom for circumferential expansion. The shrouding comprises two composite frusto-conical rings which, as shown by the fragmentary section of Fig. 2*a*, are each made up of a number of segments 27 interconnected by strips 28 which enter freely at their peripheral edges into slots in the axially-extending edges of the segments. Since expansion of the parts which make up the shrouding rings does not affect their radial dimensions, these dimensions are dependent upon those of the rigid stator structure by which they are supported; due to the shielding effect of the shrouding, and preferably also to the effect of cooling fluid flowing in a cavity 30 (Fig. 2), variation of the radial dimensions of the rigid stator structure may be kept within quite narrow limits.

Fig. 2 also serves to illustrate the next two patents in this section. The first, No. 593,918, is concerned with the relief of hoop stress in a member (such as a turbine rotor) in which there is differential thermal expansion due to a falling temperature gradient from periphery to hub portion. In the specification, the invention is described in its application to an unbladed rotor component such as is shown at 6 in Fig. 2 and itself forms part of the invention with which the next succeeding patent is concerned. The relief of stress is provided for by one or more keyhole slots, of which an example is illustrated by the fragmentary section of Fig. 3; such a slot may be formed, for example, by drilling and gashing (e.g., sawing) in the radial direction and hammering or rolling (before final machining) to burr over the edges of the gash and form lips as indicated at 3. The lips are sufficiently thin to offer no appreciable resistance to closure of the slot during thermal expansion and, even if contiguous when first formed, will usually be crushed when the rotor (or the individual component) is first heated so that a slight gap, as indicated in Fig. 3, normally exists in the cold condition; when the rotor is hot, the lips will again meet to form a continuous surface. In order to prevent by-passing of working- or cooling-fluid the slot is blocked, for example, by means of a grub screw (indicated at 9 in Fig. 2) threaded into the slot and holding in position a plug 10 located in the keyhole portion.

The invention forming the subject of Patent No. 599,829 is concerned with the provision of a rotor construction which, while being relatively easy to manufacture, is conveniently adapted for the practice of disc-cooling and gives good stress-carrying capacity. As shown by Fig. 2, a pair of bladed turbine discs 13 and 16 are separated by the unbladed disc 6. The intermediate disc has a thickened hub portion 22 having accurately machined surfaces which co-operate with complementary surfaces on flanges 24 on the bladed discs; this co-operation provides radial location of the discs 6 and 16 in relation to the disc 13. Serrated flanges 26 are formed on the discs 13 and 16, at a radius a little

POWER JETS' GAS-TURBINE PATENTS.

Fig. 5.

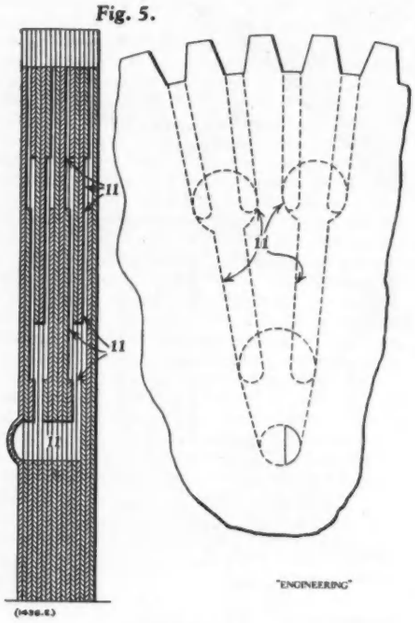


Fig. 6.

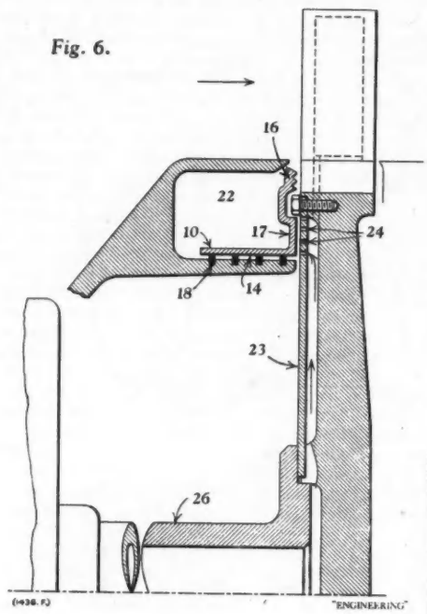


Fig. 7.

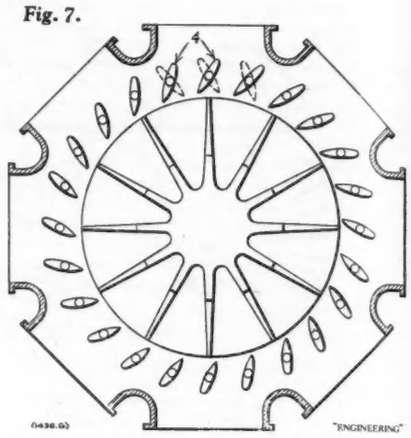
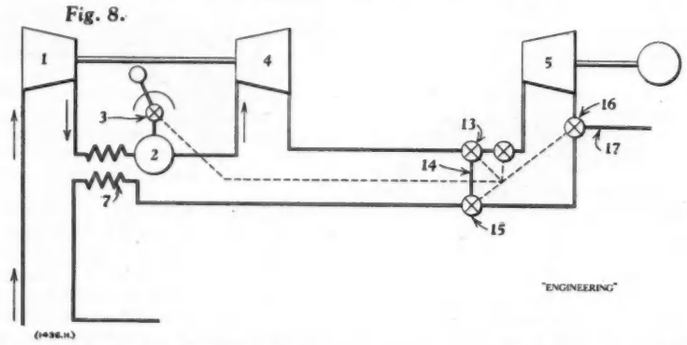


Fig. 8.



less than that of the bottom of the blade slots, and these engage serrated flanges 25 formed on the opposite faces of the intermediate disc; this inter-engagement plays no part in the mutual radial location of the discs and is concerned solely with the transmission of torque. It will be observed that only the first disc 13 is seated on the rotor shaft and that there is ample clearance between the shaft and the hub portions of the other two discs; this would apply to the remaining bladed and unbladed discs of a rotor of more than two stages. The clearances between the shaft and the discs and between adjacent discs facilitate the passage of coolant fluid, for example, as indicated by arrows.

Patent No. 609,682 relates to a variable-admission nozzle guide ring having pivotable blades, the bearings and supporting structure of which are protected against high-temperature effects. As shown by Fig. 4, page 679, the spindle of a guide blade 25 is pivoted in carbon bushes 26 and 27, the bushes and the structure in which they are mounted being shielded from the hot gas by shrouding 32, 33; the shrouding is preferably of the kind described above with reference to Fig. 2*a* or of other construction which enables it to accommodate thermal stresses due to differential expansion as between itself and the blade ring, its diameter at any time being determined by that of the blade ring. In the drawing, the reference 38 indicates ceramic bushes which may be provided to prevent binding of the spindles where they pass through the shrouding and the arrows indicate a desirable flow of cooling air around the spindle mountings. Although applicable to turbines in general the invention was in fact originally conceived in connection with gas-turbine plant to be controlled in a manner earlier described in the section on automatic control of gas turbines. (See Part IV—Patent No. 612,414.)

Patent No. 628,100 is the earliest of a block of patents under which Power Jets has acquired licensing rights from an "outside" inventor (Mr. J. Atkinson) and relating to turbine discs of laminar construction. Advantages claimed for the laminar construction are ease of manufacture and reduction of first cost and wastage-rate as compared with one-piece methods of manufacture, as well as the possibility of avoiding the use of strategic materials in view of the improvement in tensile strength obtainable through rolling of the material from which the laminæ are produced. Internal passages for coolant fluid may conveniently be provided by means of overlapping holes in adjacent laminæ, as indicated, for example, at 11 in the part section and elevation which together form Fig. 5.

The specification of patent No. 648,824 describes devices for providing a fluid seal between a turbine rotor and a stationary part of the turbine; similar devices could, of course, be used in other connections to provide fluid seals between relatively rotating members. In the arrangement illustrated by Fig. 6, a turbine disc carries on its upstream side a plate 23, which defines an annular passage for air supplied by way of a hollow shaft 26 and able to escape by way of a circumferential series of holes 24. In register with the series of holes 24 is a flat surface 17 of a seal element 10; this element has a cylindrical body portion 14, mounted to slide on resilient rings 18 carried by a fixed part of the turbine, and a flange portion which includes the flat surface 17 and a circumferential labyrinth portion 16. The seal element is located within a chamber 22, to which the working fluid of the turbine has access. In operation, the pressure of the working fluid urges the seal element toward the disc to a position in which the force exerted by the working fluid is balanced by the opposing force exerted by the jets of air escaping from the holes 24. The pressure relations are such that equilibrium occurs when the labyrinth portion 16 is spaced at a predetermined distance from the adjacent face of the disc; in this way, a satisfactory seal is obtained at all times, without any rubbing contact, independently of the effect of thermal growth of the respective parts. Patents relating to the problem of blade-cooling in axial-flow turbines will be reviewed later in a separate section.

Inward-Flow Turbines.—Although the inward-flow principle has been applied to water turbines for many years, practical application to the gas-turbine field has been relatively small up to the present. It is true that the first gas-turbine aircraft ever to fly (the jet-propelled Heinkel He 178 on August 27, 1939) was powered with a unit (Heinkel He S2) comprising a centrifugal compressor and a centripetal turbine arranged back-to-back; it is true also that the turbine in that case was of relatively high power, the thrust delivered being 450 kg. Nevertheless, more than 12 years after that first flight, the actual use of the inward-flow turbine is still negligible as compared with the axial-flow type, and the indications are that, for some time at any rate, use in the future will be limited to relatively small powers. The current interest in small gas turbines is opening up a natural field for the inward-flow turbine, and of late the type has been extensively studied by the Power Jets' consultancy team; thus it comes about that several patent applications are pending relating to structural features of the type but that only two relevant Power Jets' patent specifications have so far been published—and these relate to features of control.

Patent No. 630,164 is concerned with the problem of reverse-drive, and the specification proposes the use of an independent power turbine of the inward-flow type to which the working fluid is introduced with a swirl movement about the rotor axis. As shown by Fig. 7, fluid entering the turbine casing by a number of entries is given a swirl movement in either the anti-clockwise or clockwise sense according to the sense of adjustment of a number of pivoted vanes 4. If equal power is required for both forward and reverse drive, the vanes are of streamlined form as illustrated. If, however, more power is required for drive in one direction than the other, the vanes are appropriately cambered; similarly, the trailing edges of the vanes of the rotor

itself are curved, at outlet, in the direction opposite to the direction of rotation in which greater power is required.

Whereas the problem of reverse drive extends also to marine propulsion, that of automatically providing a braking effect when a driven shaft over-runs its engine is peculiar to land vehicles; patent No. 662,867 is concerned with this latter problem. The invention is based on the recognition that a centripetal gas turbine is, in effect, a centrifugal compressor "with its outlet where its inlet should be" and that, if the inlet be caused temporarily to become the outlet, and vice versa, the impeller will act as an inefficient compressor and absorb power from the shaft which it normally drives. In the arrangement shown diagrammatically by Fig. 8, opposite, a mechanically independent power turbine 5 of the inward-flow type normally receives hot gas, via a valve 13, from a gas-generator set comprising a compressor 1, combustion chamber 2 and compressor-driving turbine 4, the valves indicated at 15 and 16 being set so that exhaust is by way of the hot side of a heat exchanger 7. A linkage, indicated by dotted lines, is provided between the fuel valve 3 for the combustion chamber, the valve 13 and the other valves indicated at 15 and 16; this linkage is such that setting of the valve 3 for idling power is accompanied by setting of the valves 13, 15 and 16 so that the rotor of the turbine 5, acting as a centrifugal impeller, may inspire air from an intake 17 and discharge it by way of a by-pass duct 14, the exhaust from the turbine 4 being diverted through the same duct. Various alternative methods of control of the valves are described in the specification; according to one such method, the actuation of the valves for braking effect is under the control of a centrifugal governor sensitive to differential velocities of the shafts of the two turbines, as detected by a differential gear having input shafts coupled to the two turbine shafts, an over-riding control being provided to permit the application of braking effect only when the fuel valve is set for idling power.

LONDON TERMINUS FOR BRITISH EUROPEAN AIRWAYS.—On Tuesday, May 19, the new London town terminus of British European Airways was opened on the Festival of Britain site near Waterloo. The new terminal building is directly connected by escalators with Waterloo underground station. It comprises the former Festival Station Gate building, with extensions, and has been planned to ensure a smooth flow of incoming and outgoing passengers, and to handle the "processing" for 60 flights per hour. In the area adjoining the building, there is space for loading and unloading twelve 37-seat passenger coaches simultaneously. The Waterloo terminal building is a steel-framed structure with reinforced-concrete floors. Most of the new walls are of Dutch facing bricks, but the west wall is made up of uncoursed rubble from the material of demolition on the site. The ventilation shaft installed in the escalator section is subjected to wind velocities of up to 20 m.p.h. and has an area of 200 sq. ft.

INSTITUTE OF PHYSICS MONOGRAPHS FOR STUDENTS.—The first four of a series of monographs intended for general reading by students preparing for the Higher National Certificate in Applied Physics have now been published by the Institute of Physics at the price of 5s. each. These booklets are not to be regarded as text-books and are not prepared to cover any particular part of the syllabus for the National Certificate or for the graduateship examination of the Institute of Physics. They should, however, be very useful to all who wish to inform themselves on the branches of applied physics covered and to keep up to date with recent developments in them. Each is written by a specialist, and Dr. H. R. Lang, A.R.C.S., F.Inst.P., is the general editor of the series. The four monographs published are: "Fundamentals of Thermometry," by J. A. Hall, B.S., A.R.C.S., D.I.C., F.Inst.P.; "Practical Thermometry," by the same author; "The Magnetic Circuit," by A. E. De Barr, B.Sc., F.Inst.P.; and "Soft Magnetic Materials Used in Industry," also by Mr. De Barr. Further monographs in the series are being prepared; there are 50 to 60 pages in each, measuring 5 in. by 7 in. The offices of the Institute of Physics, whence the monographs can be obtained, is 47, Belgrave-square, London, S.W.1.

THE NATIONAL PHYSICAL LABORATORY.

DURING the year 1952, an increasing proportion of the work carried out by the National Physical Laboratory has been concerned with short-term investigations for defence needs, at the expense of the traditional tasks of precise measurement and systematic fundamental research. At the same time, the staff has been reduced as an economy measure and is, in fact, inadequate to cover the programme. "The Executive Committee," it is stated in the National Physical Laboratory Report for the Year 1952,* "deplores the loss to the country by the curtailment of this work of the N.P.L. and has made representations to this effect." The Committee consider also that the Laboratory, which consists of a collection of individual laboratories, united under single direction, should be provided with better community facilities so that the staff of the various divisions may have better opportunities for exchanging their ideas.

The publication of the N.P.L. annual report, on Friday, May 15, coincided with "Open Day" at the Laboratory, when guests from scientific organisations and industry were invited to inspect some of the work and facilities of the Laboratory. It is convenient therefore to consider some of the exhibits on view in relation to the activities described in the annual report. Since the programme of exhibits and demonstrations at the Open Day listed nearly 200 items, it will be understood that only a few aspects of the work can be mentioned here.

AERODYNAMICS.

Most of the work of the Aerodynamics Division during the past year has been undertaken for the Ministry of Supply, and much fundamental research work has been carried out on the problems of high-speed military aircraft at speeds approaching or exceeding the speed of sound. Much of this work can be carried out in small wind tunnels, and those at present available in the high-speed laboratory range from a 2·6-in. by 1·5-in. continuous-flow tunnel, with a Mach number range from 0 to 4, to a 20-in. by 8-in. induced-flow tunnel, with a Mach number range from 0 to 1, shortly to be extended to 1·6. Two larger tunnels, to be housed in a new laboratory, are now under construction; both are of the induced-flow type, with a Mach number range of 0 to 1·8; the smaller one, which is more advanced, has a 25-in. by 20-in. working section; the larger one, 36 in. by 14 in.

One of the exhibits on view in the high-speed laboratory showed an experiment in the 18-in. by 14-in. compressed-air tunnel designed to compare the actual flow near the leading edge of a swept-back wing and that predicted by theory, which is not exact. This is part of a systematic investigation on swept-back wings to correlate theory with experiment. The experimental observations include pressure measurements at the surface of a wing, and measurements of the lift, drag, and pitching moment using a strain-gauge balance. The latter has been developed to provide a means for rapidly recording the loads in order to make full use of the limited running time available with an intermittent tunnel.

The strain-gauge balance on view was a three-component balance in which the model is attached to a specially-designed support downstream of the model so that the shock waves produced by the support do not interfere with the flow over the model. Resistance strain gauges cemented to the support convert each of the three component forces into electric signals which are used to operate the pens of chart recorders.

Other exhibits on view in the high-speed laboratory included pressure-plotting tests on a 6 per cent. thick aerofoil section in the 20-in. by 8-in. subsonic tunnel—part of a detailed investigation on the flow round two-dimensional aerofoils at high subsonic and transonic speeds. Thinner sections, down to 3 per cent. thickness/chord ratio, are to be tested. A demonstration of the effect of varying Reynolds number and Mach number independently on the interaction of the shock wave with the boundary layer on the surface of a body was on view in the 2·6-in. by 1·5-in. supersonic tunnel. These researches have been in progress for many years, and the major features of the problem are now understood. Recent high-speed Schlieren photographs of wake flow show that when the shock waves on an aerofoil are sufficiently strong to cause boundary-layer separation, regularly spaced eddies may be present in the wake, which, it is thought, may contribute to buffeting and related phenomena observed in high-speed flight. In experiments on a flat plate at supersonic speeds, it has been found that in an adverse pressure gradient a laminar-boundary layer separates much more readily than a turbulent one.

* *National Physical Laboratory. Report for the Year 1952.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2s. 6d. net.]

ELECTRICITY.

The principal activities of the Electricity Division during the year 1952 included a new absolute determination of the ohm; precision measurements of the dielectric constants of gases and of liquids; a detailed study of the power losses in representative industrial insulating materials; studies of the corona produced by the application of surge voltages to cylindrical electrode systems, and of the current-voltage characteristics of and between copper contacts at low atmospheric pressure; and the development of standard resistors suitable for power work at the higher frequencies. Among the exhibits of the work of the Electricity Division on view on Open Day may be mentioned a 700-watt oscillator-amplifier set for frequencies ranging from 50 cycles to 2,000 cycles per second, with a stability of 0·01 per cent.; and a compressed-gas capacitor for precision voltage and power factor measurements for 500 kV (r.m.s.).

ELECTRONICS AND COMPUTING EQUIPMENT.

At least 90 per cent. of the resources of the Electronics Section have been absorbed in developing electronic digital computing equipment. They have also been collaborating with a working party of the Department of Scientific and Industrial Research on studying the application of high-speed digital computor techniques to scientific, industrial, and administrative data processing, which promises possibilities of great economies in money and man-power.

The principal exhibit of the Electronics Section on Open Day was a magnetic drum store which is being developed for the A.C.E. (automatic computing engine) Pilot Model digital computer, now in use by the Mathematical Division on problems of mathematical physics, linear algebra, ray tracing, flutter, etc. It may be mentioned in passing that an "engineered" version of the Pilot Model computer, to be known as the D.E.U.C.E., i.e., digital electronic universal computing engine, has been ordered from the English Electric Company, Limited. The magnetic drum store consists essentially of a metal cylinder, 4 in. in diameter and 4 in. long, made of a non-magnetic material, the curved surface of the drum being coated with a thin film of magnetic material. The drum rotates at high speed, driven by a synchronous motor controlled in frequency by the quartz-crystal clock which provides the "clock" pulses for the whole machine. Sixteen writing heads and 16 reading heads, consisting of tiny electromagnets, are held close to the surface. A pulse of current through any one writing head creates a permanently-magnetised spot on the drum, which can be "read" by one of the reading heads. Since any number can be represented as a train or pattern of pulses, numbers can be "written" on the drum, "remembered," and read off at any subsequent time. Both writing and reading heads can be shifted axially to a second position, so that 32 tracks on the drum can be used. Each track can store 32 numbers, so that the total memory capacity is 1,024 numbers, each equivalent to ten decimal digits.

LIGHT.

The transparent electrically-conducting films deposited on glass, which have been developed by the Light Division during 1952, were described in our report on the 1952 Open Day, on page 804 of our 173rd volume (June 27, 1952), in which mention was also made of the application of the Merton integrating nut for producing diffraction

gratings. This year examples were shown of such gratings applied to the production of linear scales of exceptional accuracy; the accurate measurement of length by an electronic counting machine; and the production of a slow uniform rotary motion, such as is often required in optical instruments.

METALLURGY.

Fundamental studies of the elastic and plastic deformation of metals and of the embrittlement of iron at low temperatures, work on the improvement of refractories for very high temperatures in rocket applications, investigations on the creep of high-temperature metals and alloys, and on the preparation and properties of titanium and some of its alloys, were part of the work of the Metallurgy Division during 1952. One of the exhibits on Open Day showed the method employed for determining the melting point of titanium, a difficult problem because of the highly reactive nature of the metal, which is contaminated by contact with any known refractory material. In the N.P.L. method, a small cylindrical specimen of titanium, about $\frac{3}{4}$ in. long and $\frac{1}{4}$ in. in diameter, rests in a zirconia crucible, in the lid of which is a sighting hole. A recess in the base of the specimen ensures that only a small area of metal is in contact with the crucible. During an observation, the filament of an optical pyrometer is focused on the base of a small axial hole drilled in the specimen. The latter is heated slowly in a furnace consisting of a tungsten spiral surrounded by radiation shields of tantalum and molybdenum foil. The spiral, shields and electrodes are enclosed in a water-cooled evacuated cylinder. When melting begins, molten metal fills up the hole in the specimen and disturbs the black-body conditions. The furnace is shut down before the specimen collapses and reacts with the crucible. By this means, a mean value of 1,660 deg. C. has been obtained for the melting point of titanium, which is considered to be accurate within ± 10 deg. C.

The High-Temperature Mechanical Properties Section, now forming part of the Metallurgy Division, has been concerned with long-time creep tests of components of high-temperature steam-power and gas-turbine plant; creep relaxation tests on bolt materials; and the investigation of the effects of rate of stress application on the fatigue strength of metals at high temperature. Equipment for carrying out creep tests at temperatures up to 1,400 deg. C. was on view in the creep laboratory, in which a Glowbar furnace and an extensometer in a ceramal is employed. On view in the high-temperature fatigue laboratory was an exhibit illustrating investigations which are in progress on the effect of plastic deformation on the notch sensitivity of metals under repeated loading.

METROLOGY.

During 1952 the Comité International des Poids et Mesures set up an advisory committee to study the definition of the metre; any new division resulting from this study will probably be in terms of the vacuum wavelength of an isotope line. Other work carried out by the Metrology Division includes developments in microwave interferometry, in precision barometry, in the determination of the density of mercury, in the electronic simulator for studying the performance of closed-loop control systems, and in techniques of measurement and control.

Also on view was a new gauge-measuring interferometer for the routine measurement of high-quality gauge blocks of lengths up to 4 in. in terms of wavelengths of light. Up to 20 gauges can be set up for measurement on a rotatable flat steel baseplate so that each gauge may be brought in turn to the centre of the field of view for measurement. A mercury-198 lamp and a cadmium lamp are incorporated in the new instrument to provide a suitable selection of monochromatic radiations of known wavelength. Three or four radiations of different colours, selected by the lamp and prism controls, are used in sequence to illuminate the field of view. A visual estimation is made, for each radiation, of the relative displacement between two sets of parallel interference fringes, one of which is viewed over the upper surface of the gauge and the other over the baseplate. With practice, such an estimate can be made to one-twentieth of the fringe spacing, corresponding on the average to 0·5 micro-inch in length. The size of each gauge is derived by comparing the observed displacements with tabulated standard values; any difference is evaluated by using a special slide rule which automatically gives the result expressed as a difference from the nominal length of the gauge, corrected for temperature.

Also on view were, among other things, two new instruments for measuring holes; one of these, still under development, is a pneumatic comparator for evaluating holes from 2 in. to 4 in. in diameter. The other instrument is an optical comparator for small high-precision ring gauges, capable of measuring to within 0·00001 in. Various examples of the use of steel flexure strips—as hinges, cross-spring pivots, magnifying linkages, etc.—were shown. A method for manufacturing and measuring delta-wing aerofoils for use in the high-speed tunnels was also shown. In theory, the models can be made to any degree of accuracy by cutting a large number of tangential planes enveloping the form required. The Metrology Division method comprises a precise rotation and tilt of a blank under a precisely-set milling cutter, to generate the required tangential planes. In practice, mild-steel or brass models are made by cutting a limited number of planes which leave 0·0005 in. excess metal at the intersection of consecutive planes. This excess metal is removed with fine emery cloth, and the whole surface is finished smoothly by hand. The accuracy is within 0·001 in. of the required form.

To check the form, the aerofoil models are clamped to the worktable of a measuring machine by an accurately ground lug formed on the model during manufacture. The worktable can be moved in a horizontal plane in two mutually perpendicular directions to an accuracy of ±0·00002 in. A microscope with a very short depth of focus (about 0·0002 in.) can be moved, by precisely known amounts, perpendicular to the worktable. By setting the horizontal movements of the worktable and adjusting the vertical position of the microscope until a local area of the surface of the model is in focus, the co-ordinate positions of any number of such areas, relative to the three axes of movement of the machine, can be obtained.

PHYSICS.

The Physics Division was concerned during 1952 with a wide range of activities, most of which were illustrated by exhibits in the Laboratory. Among them may be mentioned the standardisation of radioactive isotopes; measuring the thermal conductivities of material for high-temperature insulation and for refrigeration work; investigating methods for silencing jet-engine test houses, and noise transmission in ships; measurements of the elastic constants of solids by ultrasonic techniques, and developing ultrasonic flaw detectors. In the Engineering Section of the Physics Division, a large tensile impact testing machine has been in almost constant use testing electrically-welded steel chains. All lifting chains are subjected to a proof load of twice the working load before they go into service, and samples are tested to failure under a sudden pull from a pendulum weighing 2 tons, which reveals slight imperfections in welding not so readily detected under static loading.

Also on view was a demonstration of the Collins Helium Cryostate, the first commercial plant for liquefying helium to be installed in the United Kingdom. Liquid helium, which boils at — 452 deg. F., is used for cooling materials down towards absolute zero. The plant is to be used, in the first place, for measuring the entropy of pure chemicals. It will also be used for standardising thermometers and for studying the crystalline properties of metals. When cooled below —455 deg. F., liquid helium cannot be contained in an unstoppered vessel, since it creeps rapidly over the mouth of the vessel. It also transmits temperature waves in the same way as other substances transmit sound.

SHIPS.

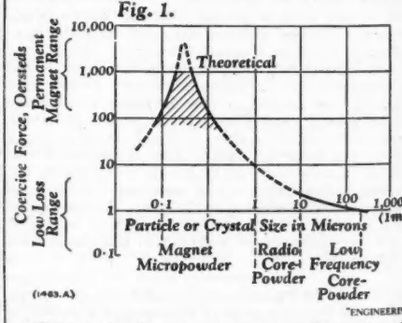
In addition to investigations of hull and propeller designs, and research work on hull models for comparison with full-scale trials, the Ship Division have been carrying out surface friction experiments in connection with international discussions on the desirability of replacing the Froude method for predicting surface resistance by more modern concepts. In this connection, work is now in progress on large pontoons, floating at very small draught, in the towing tank. The pontoons are made in units 15 ft. long and 4 ft. wide, with end units 8 ft. long, and are of light wood construction, with bottom and sides covered with plastic sheets giving a smooth waterproof finish. The units are arranged in various combinations to give a range of lengths and widths; a maximum length of over 200 ft. is envisaged. The tests extend to Reynolds numbers up to about 100 million and, in conjunction with other work on planks and fully-submerged planes, a range of Reynolds numbers from 0·1 to 100 million is covered. The length-to-breadth ratio ranges from less than 1 to about 50.

Among other exhibits on view in the Laboratory may be mentioned a demonstration of the closed-circuit water tunnel, recently refitted, to be used for measuring the pressure fluctuations about a rotating propeller. The torque and thrust of the propeller, which is stroboscopically lighted, are measured by a dynamometer. Pressure pick-ups transmitting signals to a cathode-ray oscillograph enable the water pressure to be explored, providing information on the effect of the proximity of the propeller to the tunnel walls, or to a ship's hull. Tests on rudder effectiveness were also demonstrated in one of the towing tanks. The rudder angle and propeller revolutions of the model are controlled remotely from the towing carriage spanning the tank. The model is set in motion on a straight course down the tank at a representative speed, and the rudder is then put over, at a rate corresponding to 2 deg. per second for the ship, to an angle of 5 deg. port. When this angle is reached, the rudder is put over to 5 deg. starboard. The response times are measured, and the tests are repeated at progressively larger rudder angles. The time measurements are the square root of the model scale multiplied by the corresponding ship times.

MICROPOWDER MAGNETS.

MAGNETIC materials are customarily divided into two classes—soft and hard—depending on their mechanical qualities. When, however, certain compounds of irons are converted into metallic powder, consisting of very small particles, by a hydrogen reduction process at low temperatures, the product is mechanically soft and can be moulded without a binder. As a result, solid and stable permanent magnets with an energy factor equivalent to that of the best cobalt steel, but with nearly half its physical density, can be made. Chemical compounds can also be reduced at higher temperatures and used to produce both pure iron and iron-alloy magnetic powders, the losses of which are low. Such powders have been made by chemical reduction methods in the Research Laboratories of the General Electric Company, Limited, for some 25 years, and the process has now been developed on a commercial scale by their associated concern, Salford Electrical Instruments, Limited. The advantage of employing chemical methods for this purpose is that they enable powders both of pure iron and of a wide range of alloys to be made with any required size of particle.

Fig. 1.



It has further been known for some years that the coercive force of iron powder is at least partly dependent upon the particle size. It has also

MICROPOWDER MAGNETS.

GENERAL ELECTRIC CO., LTD., LONDON.

FIG. 2. POWDER MIXER.

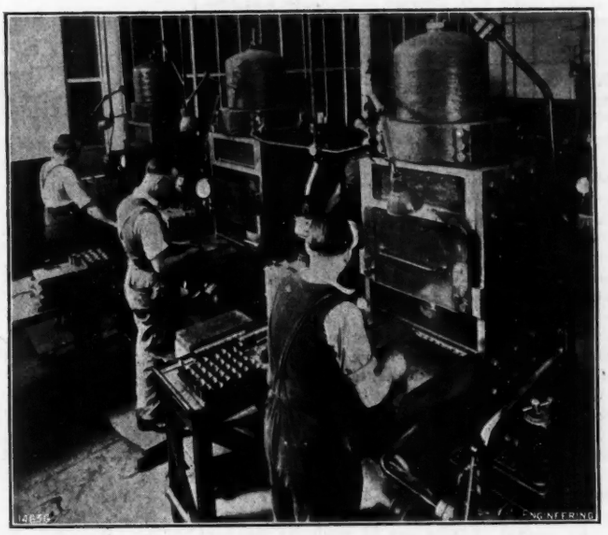


FIG. 3. PRODUCTION OF MAGNETS.

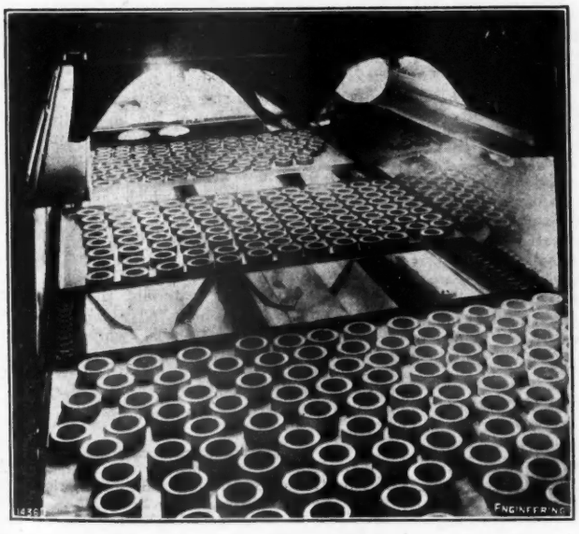


FIG. 4. INFRA-RED DRYING OVEN.

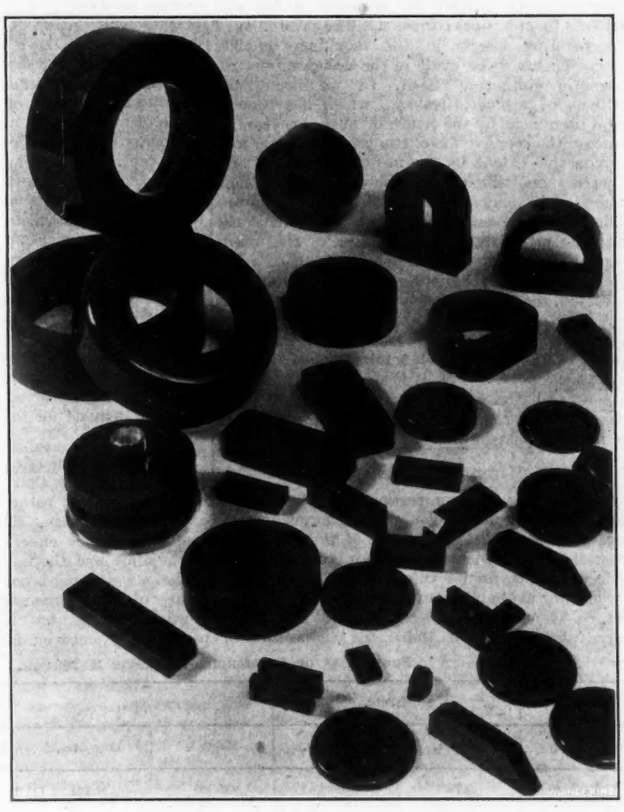


FIG. 5. TYPICAL GECALLOY MAGNETS.

been found experimentally that coercive forces approaching 1,000 oersteds can be obtained by reducing pure iron from ferrous formate in dry hydrogen. The best results are obtained with particles the crystal size of which is from 0·01 to 0·1 micron, the coercive force falling rapidly to values inadequate for permanent magnet work below this figure. Theoretically, the maximum coercive force of pure iron is some 10,000 oersteds, if it is assumed that the particles are elongated and of optimum dimensions, oriented in one required direction. These results are shown in the graph, Fig. 1, which indicates the approximate values of the coercive force plotted on a logarithmic scale for the appropriate range of particle size. It shows how the same raw material, pure iron, in powder form, can be used to provide two grades of magnetic material; of which the coarse range, with crystal sizes above 1 micron, is of practical value since its loss is low, while the micropowder range, with crystal sizes below 0·1 micron, has useful permanent magnetic properties. Improved magnetic performance can be obtained by utilising micropowders of certain magnetic iron alloys, especially those containing 30 per cent. of cobalt. Owing to the high price of this metal, however, cheaper grades containing lower percentages of this metal are made; or pure iron prepared from less expensive raw materials is used. The wider employment of micropowder magnets should therefore result in a considerable saving in imported materials.

LINES OF DEVELOPMENT.

Micropowder magnets were first developed by the French metallurgical company, Société d'Electrochimie, d'Electrométallurgie et des Aciéries Elec-

triques d'Uguine, and the Gecalloy magnets, of which examples are illustrated in Fig. 5, on page 683, are now being made under licence from that firm by the General Electric Company. They are moulded under high pressure in the factory as illustrated in Fig. 3, on page 683, a process which increases their remanence in proportion to their physical density and improves their mechanical strength. The mechanical strength can be further increased by mixing the metal with plastic binders. Former difficulties which arose from the low density and the highly pyrophoric nature of the micropowders have been overcome; it is now possible to produce magnets in quantities from these materials with a density of from 4 to 5 gm. per cubic centimetre. This is a 40 per cent. reduction on the corresponding figure for most steel magnets. As a result of this lower density, a ton of micropowder will produce nearly twice the number of magnets as a ton of steel, thus representing an important advantage both to designer and user. Where high remanence is required, the micropowders can be used alone and will have a low resistivity which can, however, be increased by adding a suitable binder.

Owing to the softness of the micropowders they can be accurately moulded and subsequent grinding is unnecessary. Moreover, as only low temperatures are employed during their production, shafts, pole pieces or inserts of other metals can be incorporated in the mouldings. Alternatively, when small quantities or samples are required, micropowder magnet systems can be made by shaping and grinding pressed compacts. In all cases the magnets are sprayed with green plastic, which gives them a smooth, durable and attractive surface and protects them against corrosion. The possibility of incorporating inserts in the mouldings enables improvements to be made in the design of electromagnetic equipment itself. In particular, the problem of magnetic leakage, which has become more prominent by the tendency in recent years to increase the coercive force, has been overcome to a considerable extent by the use of cup-shaped and other designs, which the employment of the new material has rendered possible. Such designs are difficult or impossible to produce in conventional magnetic materials, especially those of the anisotropic types. Moreover, the employment of solid-steel magnets for alternating-current circuits being restricted, the use of magnets of high resistivity and negligible eddy-current losses should render improved performance possible. Fig. 2, on page 683, illustrates the heated dough mixer which is used to heat the powder after it has received its plastic coating, and Fig. 4, on the same page, shows the infra-red drying oven through which the magnets are passed after painting.

MAGNETIC PROPERTIES.

As regards magnetic properties it may be recalled that the energy factor of a permanent magnet in mega-gauss-oersteds is a measure of the maximum external energy which can be maintained by each cubic centimetre of its volume. The best micropowder now available is an alloy containing 30 per cent. cobalt and has an energy factor of 1·7, which is equivalent to that of Alnico, the composition of which is 13 per cent cobalt, 10 per cent. aluminium, 18 per cent. nickel, 6 per cent. copper and 53 per cent. iron. The density of this cobalt micropowder is about 4·5 gm. per cubic centimetre which is equivalent to that of the best cobalt steel. The energy factor of the latter is, however, only 0·95 while its density is 8·1 gm. per cubic centimetre, so that there is an advantage of 3 to 1 in raw material utilisation in favour of the powder. The lowest grade of micropowder magnet now being made has an energy factor of 0·5 and is thus equivalent to a 9 per cent. cobalt steel in magnetic energy. These figures show that, generally speaking, the quality of micropowder magnets is about the same as that of the permanent magnets available just before the war. Their magnetic properties are exercised in all directions and they are therefore known as isotropic or non-directional. More recently, it is true, Alcomax cast magnets with strongly anisotropic, or directional, properties have been introduced and give a threefold increase in energy factor, principally in remanence. These advantages are, however, only obtainable in certain designs and under special conditions, so that there is still a considerable demand for isotropic magnets with lower energy factors.

One of the chief advantages claimed for micropowder magnets is that the ratio of remanence to coercive force (or permeability) can be controlled over a wide range. The properties of existing steel magnets are closely dependent on the nature of the alloy and the method of manufacture used, so that a wide range is necessary to meet the requirements of the equipment designer. With micropowder magnets, on the other hand, values of permeability between 50 and 5 can be obtained simply by varying the manufacturing methods, in order to meet diverse practical demands.

To maintain the mechanical strength of the high coercive force grades of micropowder magnets, the physical density of which is low, a suitable plastic binder is used. This has the advantage of producing a very high resistivity and opens up considerable possibilities for the use of such magnets in alternating-current circuits. Further, the important qualities of stability and constancy of performance over long periods under severe operating conditions are obtainable by using materials with a coercive force of from 400 to 700 oersteds.

The accompanying table enables the typical basic properties of the metal powder group of magnetic materials to be compared with those of the steel and ferrite groups, the latter including all non-metallic magnetic materials. The low-loss materials have been included between groups and in each group. Both the powder and ferrite groups have the advantages that they can be moulded into various shapes and can be made with high resistivities, thus enabling designs to be improved, especially for operation at the higher frequencies. Materials in the ferrite group, however, suffer under the disadvantage of having low saturation and remanence. They are thus unsuitable for the majority of applications in which small air gaps are used. On the other hand, they possess high coercive force, which makes them suitable for magnets with large air gaps or for operation under repulsion conditions. As regards physical density and economy in raw materials, the powder and ferrite groups both have advantages over the conventional steel materials, while as regards manufacture members of the powder group are pre-eminent, chiefly because they can be moulded to dimensions by quantity-production methods. It is also possible to make accurate mouldings of magnetic systems.

PROPERTIES OF COMMERCIAL MAGNETIC MATERIALS.

Group.	Steels, etc.		Powders.		Ferrites.	
Type.	Magnet.	Low Loss.	Magnet.	Low Loss.	Magnet.	Low Loss.
Basic Material.	Solid Metal.	Sheet Metal.	Metal Micropowder.	Metal Powder.	Mixed Oxides.	Mixed Oxides.
Physical Properties.	Hard.	Soft.	Soft.	Soft.	Hard.	Hard.
Density, gm. per cub. cm.	7 to 8		4 to 5	5 to 7	4 to 5	
Resistivity.	Low (Conductor)		Low or High		High (Insulator)	
Saturation Flux Density.	High		Medium-High		Low	
Remanence / Coercive Force	High / Low-Medium		High-Low. Can be varied		Low / High	
Construction	Solid Alloy Ground to Size	Assembled Laminations	Moulding to Accurate Size with Inserts, Pole Pieces, Shafts, etc.		Moulding, Sintering and Grinding to Size	

SMALL HELICAL TORSION SPRINGS.—A paper on "An Investigation of Small Helical Torsion Springs" has been prepared by Dr. W. R. Berry, M.Sc., for the Institution of Mechanical Engineers. The object of the investigation was to obtain data for the future design of helical torsion springs of round, patented, plain-carbon spring-steel wire. Using patented wire springs it was found that when the maximum stress was compressive it was also the dominant feature with springs of a small index (the index being mean spring diameter divided by the radial thickness of the section of wire), and with those of large index the yielding was due to the smaller tensile stress at the extrados, and that a critical ratio existed where yielding occurred simultaneously at both extrados and intrados; a finding that was thought to be of considerable practical value. It has been suggested that this critical ratio may be due to the combined effect of low-temperature heat treatment and strain-age-hardening. Written discussion is invited on this paper, and all communications should be received before June 20.

A SHIP'S ELECTRICAL EQUIPMENT.

GENERAL ELECTRIC CO., LTD., LONDON.

(*For Description, see Opposite Page.*)

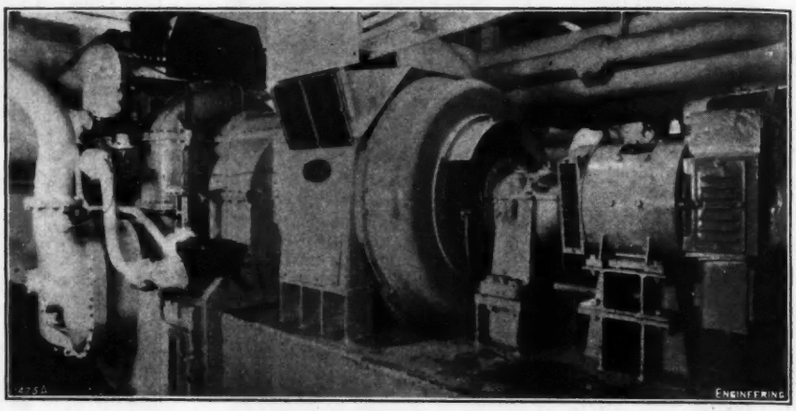


FIG. 1. 550-KW 440-VOLT ALTERNATOR.

ELECTRICAL EQUIPMENT OF S.S. "SAN FLORENTINO."

GENERAL ELECTRICAL CO., LTD., LONDON.

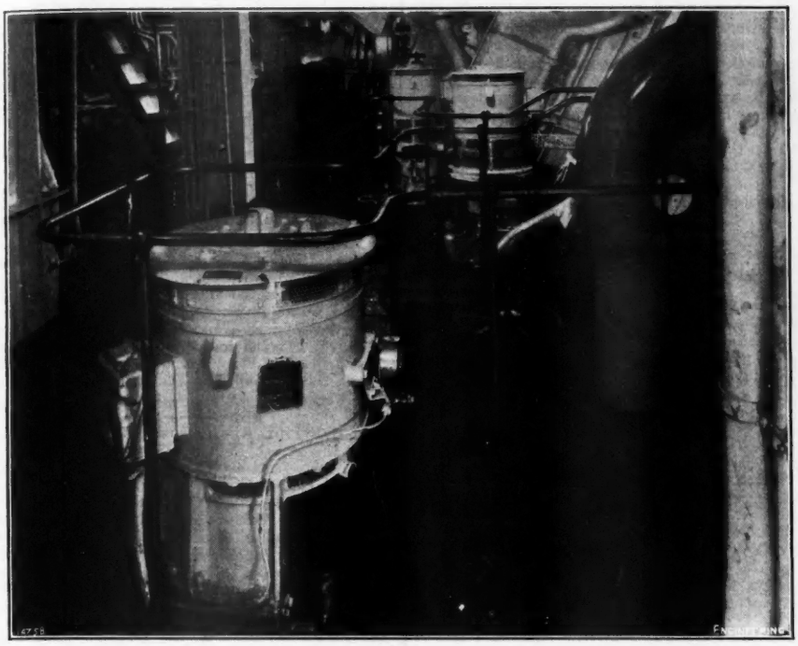


FIG. 2. 56-H.P. CIRCULATING-PUMP MOTOR.

THE ELECTRICAL EQUIPMENT OF S.S. "SAN FLORENTINO."

ALTERNATING-CURRENT electrical equipment has been installed on s.s. San Florentino, which has been built by Messrs. Cammell Laird and Company, Limited, Birkenhead, for the Eagle Oil and Shipping Company, Limited, with the major object of reducing maintenance costs. The main generating plant consists of two Brotherhood turbines, which are supplied with steam at a pressure of 500 lb. per square inch and a temperature of 800 deg. F. and drive General Electric alternators, each of which has a three-phase output of 550 kW at 440 volts and 60 cycles. These machines, which are illustrated in Fig. 1, opposite, are of the salient-pole type. They run at 1,200 r.p.m. and are directly coupled to their main exciters, the fields of which are fitted with a Newton automatic voltage regulator. In addition, there is a pilot exciter, which is driven by a V-belt. The alternators, together with the voltage regulators, are designed so as to ensure minimum voltage drop and rapid voltage recovery on peak loads, especially when the larger motors are switched direct-to-line. There is also a stand-by and port alternator with an output of 200 kW at 600 r.p.m. which is driven by a Polar engine.

The main switchboard, for the manufacture of which the General Electric Company, Limited, Kingsway, London, W.C.2, were responsible, in common with most of the electrical equipment, is 14 ft. long. It includes panels for controlling the 200-kW and 500-kW alternators, the feeders for the port and starboard group starters and the other distribution circuits. There is also a synchronising panel. As the use of 440 volts necessitates the employment of fully enclosed and protected switchgear, the General Electric Company have adapted one of their latest design of cubicles for marine duties. These cubicles are made in a number of standard widths and are constructed so that no supporting framework is necessary. The sides and top plates are made of steel sheets, the edges of which are bent into U's, those on the inside being bolted together to form a rigid structure. The bottom of the cubicles is mounted flush with the deck and both the front and rear doors are carried on invisible hinges so that the spacing between them is only ¼ in. The switchgear itself is mounted on panels which, in turn, are carried on an internal skeleton frame. All parts which may normally require attention are accessible from the front, rear access being generally only necessary for the inspection of the main 'bus-bars and other interconnections. Interlocking is provided so that these doors can only be opened after the live parts have been isolated. The circuit-breakers for the generators and main feeders are of the withdrawable type and have a rupturing capacity of more than 12 MVA. Those controlling the 550-kW alternators are electrically operated, occupy the whole height of the cubicle and can be withdrawn on rollers at deck level. The smaller breakers are manually operated and each occupies half the height of a cubicle. Each breaker is connected to the 'bus-bars through a number of plugs and, when open, can be withdrawn to the isolated position without opening the cubicle door.

The electrically-driven engine-room auxiliaries are supplied from the main switchboard through an all-insulated 440-volt system. They range from a feed pump which is driven by a 178-h.p. motor to a small Drysdale pump, which is operated by a 4·5-h.p. motor. Their appearance will be clear from Fig. 2, which shows a 56-h.p. motor driving the main circulating pump. Generally speaking, these motors are of the squirrel-cage type, the only two-speed machines being the 58/25-h.p. motors driving the forced-draught fans at 1,160/870 r.p.m., the 30-h.p. motors driving the bilge pumps, the 15-h.p. motor on the La Mont boiler pump and the 5·5/2·3-h.p. and 7·5/4-h.p. motors operating the ventilating fans in the engine room. With the exception of the 178-h.p. machine, which is fitted with an air-cooled auto-transformer, all the motors are started direct-to-line and are of the simplest type with single-winding rotors. Although in this way starting currents up to six times the full-load current are incurred, the alternators can meet the demand. The majority of the motors are enclosed ventilated drip-proof machines with interchangeable terminal boxes and glands and ball and roller bearings. The motors driving the forced-draught fans and the turning and steering gear motors, however, have plain journal bearings. It is claimed that the simple design of the motors ensures maximum reliability with reduced size and lower first costs and running costs, especially in such cases as those driving the continuously-running axial-flow fans in the ventilating trunk, which are inaccessible.

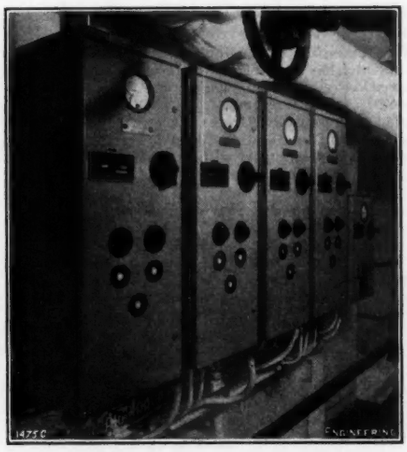


FIG. 3. DIRECT-ON MOTOR STARTER.

The motors driving other auxiliaries, such as the turning and steering gear, are supplied through a 440-volt feeder, which is carried forward to the midship house. They are controlled by two groups of motor starters which, as will be seen in Fig. 3, are housed in cubicles like those containing the switchgear, the contactors, fuses and other components being mounted on the front of the panel and the isolating switches being interlocked with the doors. By assembling the starters in multiple cubicles in this way it has been possible to reduce the number of feeder circuits with their associated circuit-breakers and switch fuses, which would otherwise be required on the main switchboard. The push buttons used for starting and stopping are, however, conveniently arranged close to the motors themselves.

Other distribution circuits which supply small power appliances and lighting through air-cooled transformers at 115 volts are controlled by on-load, quick make-and-break switches which embody high rupturing capacity fuses. The General Electric Company have also equipped the vessel with 440-volt and 110-volt cooking and water-heating apparatus, as well as with a number of cabin fans and other fittings.

CONFERENCE ON INDUSTRIAL APPLICATIONS OF STATISTICS.—The Royal Statistical Society, 4, Portugal-street, London, W.C.2, is arranging a week-end conference on "Industrial Applications of Statistics," to be held at the College of Aeronautics, Cranfield, Bedfordshire, from Friday, September 25, to Sunday, September 27. It is hoped to provide a choice of two or more papers at each session. Titles of papers already accepted include "Analysis of a Complex Experiment," "Use of Nomograms in Statistics." "Solution of Normal Equations," "Subjective Testing," "Comparison of Averages for Industrial Time Series," "Labour Turnover," "Machine Stoppage Rates," "Quality Control with Samples of One," and "Teaching Statistics for Industry."

PRIZES FOR THE IMPROVEMENT AND ENCOURAGEMENT OF NAVIGATION.—As in previous years, the Council of the Royal Society of Arts is offering a prize of 50*l.*, under the terms of the Thomas Gray Memorial Trust, for an essay by a seafarer, of British nationality, who has served afloat in the merchant navy since January 1, 1951. The subject chosen for this year's competition is "The Improvement of Cargo-Handling Appliances Both on Board Ship and at the Quayside; with Special Reference to the Need for Self-Sufficient Arrangements in Times of Emergency and the Over-Riding Consideration of Keeping Costs Low." Essays should not exceed 7,500 words and should reach the Society not later than December 31, 1953. In connection with the Trust, the Council are also offering a prize of 50*l.* for a deed of outstanding professional merit performed by a member of the British merchant navy during the year ending September 30, 1953. Details of the deed must be submitted not later than December 31 next. Further particulars may be obtained from the secretary of the Society, John Adam-street, Adelphi, London, W.C.2.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

GLASGOW PRODUCTIVITY COMMITTEE.—A productivity committee to distribute worthwhile information to industry has been formed in Glasgow after a meeting convened by the Glasgow District Committee of the Scottish Board for Industry. The committee is to include representatives from the City's major industries, the trade unions, and the Royal Technical College. The nucleus committee, with powers to co-opt others, includes Mr. John Murray, of the Mirrlees Watson Co., Ltd., who is chairman, and Mr. James Lambert, of the I.C.I. Nobel Division, Glasgow, the vice-chairman.

AIR TERMINAL FOR GLASGOW.—An approach to Glasgow Corporation to provide a municipal air terminal in which all operating companies would have booking and handling facilities is to be made by the Scottish Advisory Council for Civil Aviation in co-operation with the International Air Lines Committee. It has been estimated that accommodation will be required for more than 200 office staff and attendants and that the cost of a building would be between 60,000*l.* and 70,000*l.* at least. British European Airways meanwhile, however, are proceeding with their own arrangements for a terminal in the centre of the City, and premises leased will be used also by the British Overseas Airways Corporation.

NEW INDUSTRIES FOR KILSYTH.—Steps to attract new industries to offset the possibility of unemployment in the Kilsyth area, after the mines in the district are exhausted within the next ten years or so, have been advocated at a conference of local M.P.s, representatives of the Scottish Council (Development and Industry), and other interested parties, at Stirling. Reference was made to the trade recession in the light-castings industry and the need for alternative employment.

BRIDGES OVER RIVERS.—Departing from their pre-war plan for a two-pier road bridge to span the river Ness in place of the existing structure standing below Inverness Castle, the Inverness Corporation, on May 19, selected a single-span erection of pre-stressed concrete from three designs prepared for submission to the Ministry of Transport. In southern Scotland, the Peebles Town Council have been given permission to construct a footbridge over the river Tweed near Neidpath Castle, provided the cost does not exceed 6,000*l.* Mr. John S. Fotheringham, a former mayor of Johannesburg and a native of Peebles, gave 5,000*l.*, in 1948, for the erection of the bridge, but up till now there have been difficulties in the way of placing the contract.

COLLIERY PIT-HEAD BATHS.—New pit-head baths at No. 1 Colliery, Twechar, Eastern Dumbartonshire, which have been ready for a considerable time but could not be operated for lack of water, have now been brought into service. They will cater for 400 men at the colliery.

CLEVELAND AND THE NORTHERN COUNTIES.

FUTURE OF N.W. DURHAM.—A deputation from the North-East Development Association and the Northern Industrial Group has met Mr. Henry Strauss, Parliamentary Secretary of the Board of Trade, to discuss the future of North-West Durham. The deputation was led by Lord Ridley who pointed out that North-West Durham was bound to be faced with a problem owing to the decline in the area's coal-mining industry. He asked the Board of Trade for an assurance that it recognised this problem and would take measures to deal with the situation when it arose. He asked whether the Board intended to use its powers under the Distribution of Industry Acts. Mr. Strauss replied that the Board of Trade was aware of the future problem of North-West Durham. The matter was being considered by the National Coal Board, but it could not yet be foreseen where, when, and, to what extent, the problem would actually arise.

NEED FOR COMPETITIVE PRICES IN TENDERING.—The North-East Engineering Bureau, Newcastle-upon-Tyne, have issued a report to their member firms urging the need for more competitive prices in tendering for work. The Bureau state that a recent analysis has shown that prices quoted by various firms, for the same order, have varied considerably. Firms are urged to examine their costing systems and to bring their quotations to the lowest possible economic level. They are also urged to submit their quotations promptly after receiving an inquiry.

ACTIVITY OF NEW PRODUCTION COMMITTEES.—The Northern Regional Board for Industry is circularising firms in the district urging them to attend meetings of production committees to be set up in the region. It is proposed to appoint four of these committees to serve Tyneside, Wearside, Tees-side, and Cumberland and Westmorland. The last-named will be based at Carlisle. These committees are being set up at the request of the British Productivity Council.

THE LATE MR. J. H. H. CLARK.—The death has occurred at Sunningdale, Berkshire, at the age of 95, of Mr. James Henry Havelock Clark, son of the founder of Messrs. George Clark (1938), Ltd., marine and land engine builders, Sunderland. Mr. J. H. H. Clark took over the control of the firm until 1938 when it was amalgamated with Richardsons, Westgarth & Co., Ltd., and the North-Eastern Marine Engineering Co., Ltd. He then retired and left Sunderland to live at Sunningdale. Mr. Clark was formerly a member of the River Wear Commissioners for 28 years.

THE LATE MR. J. S. WOOD.—The death has taken place at West Hartlepool, at the age of 60, of Mr. J. S. Wood, secretary of the Hartlepools Port and Harbour Commissioners for six years until his retirement last year, owing to ill-health.

LANCASHIRE AND SOUTH YORKSHIRE.

RENISHAW BLAST FURNACE.—Members of the Sheffield and District branch of the Institute of British Foundrymen have been especially interested in the preparations being made at the works of the Renishaw Iron Co., Ltd., for the building of a new 1,500-tons a week capacity blast furnace to replace one of the existing two 1,000-ton capacity furnaces. It is expected that the new furnace will be in production within the next 18 months.

IMPORTS OF MACHINERY.—The Sheffield Chamber of Commerce is to press the Board of Trade to allow duty-free importation of foreign machinery in cases in which equivalent home-produced machinery is unobtainable, or cannot be delivered within a reasonable time. It is also recommended that machine parts and accessories should be treated in the same manner.

HIGHER COAL PRODUCTION.—In the Whitsuntide "bull" week, Yorkshire miners achieved a record pre-holiday production with 1,063,500 tons which was 31,000 tons more than in the previous week. Production would have been higher still had it not been for an underground fire at Shireoaks which brought the colliery to a standstill, and resulted in a loss of 7,000 tons of coal. Doncaster-area pits had their best week since the Christmas "bull" week of 1951, the output having been increased by more than 11,000 tons to 208,180 tons.

SOUTH YORKSHIRE COLLIERY IMPROVEMENT SCHEME.—Plans for making extensive improvements at Denaby and Cadeby collieries in South Yorkshire have been approved by the National Coal Board. When completed, they will have the effect of increasing the output of coal from these pits by about 250,000 tons a year. The proposals include the construction of underground roads to link the two collieries and enable all coal produced at Denaby to be transported to Cadeby. The scheme, which will cost about three and a half million pounds, will enable a considerable redistribution of the labour force at the collieries to be put into operation, thereby resulting in an increase of production per man-shift. The scheme is not expected to be completed until the end of 1957.

DEATH DUTIES CAUSE ENGINEERING WORKS TO CLOSE.—It was reported last week that J. and J. Ingham & Co., Ltd., sheet-metal rollers and galvanisers, Hunslet Nail Works, Leeds, 10, are to close down at the end of this month, owing to the need for raising money to meet the death duties on the estate of a former owner of the business. The firm was established about 150 years ago and was incorporated as a limited liability company in 1902. The company's managing director, Mr. H. O. Pridmore, has stated that the plant and other assets are to be put up for sale.

THE INSTITUTE OF WELDING.—The spring meeting of the Institute of Welding was held in Sheffield from May 7 to 9. The programme of the meeting included a series of works visits and the reading and discussion of papers. At the technical session held on the morning of May 8, the President of the Institute, Mr. A. Robert Jenkins, presented the 1952 Sir William J. Larke Medal to Mr. J. Rannie, and the C. W. Hill Prize to Mr. A. D. Barker. The latter presentation was not made by the Master Cutler as mistakenly stated on page 473, *ante*. A dinner was held at the Royal Victoria Station Hotel that evening, at which the principal guests were the Lord Mayor of Sheffield, Alderman Peter Buchanan, J.P., and the Senior Warden of the Cutlers Company, Mr. R. L. Walsh.

THE MIDLANDS.

CONSUMPTION OF WATER IN BIRMINGHAM.—The Water Department of the City of Birmingham have issued figures showing that the water consumption in the Department's area of supply was 48·1 million gallons a day for the five-week period ending April 23. This shows an increase over the corresponding period of last year, when the figure was 47·5 million gallons. The Department have also reported good progress on the laying of the fourth main of the 60-in. syphon section of the Elan aqueduct, which brings water to Birmingham from the reservoirs at Elan and Claerwen.

FOUR ASHES CHEMICAL WORKS.—The new works of the Midland Tar Distillers, Ltd., at Four Ashes, near Wolverhampton, are so far advanced that the company have offered to transfer a number of men there from the existing works at Oldbury, about 14 miles away. The new works are an important feature of the company's development plan, which was started in 1947, and provides for the production of increased quantities of tar acids. Additional crude-tar distillation equipment is being installed at Oldbury, and the tar-acid plant is being concentrated at Four Ashes.

POWER-STATION ALTERATIONS.—The Midlands Division of the British Electricity Authority have started to clear away the remaining buildings of the old Ocker Hill power station, Tipton, Staffordshire, to make room for additional plant. The old part of the power station closed down in March of this year, at which time the generating equipment consisted of a 5-MW Brush and a 13·5-MW English Electric turbo-alternator. When the new equipment is installed, the output of the station will be trebled. Ocker Hill power station first went into commission about 50 years ago.

OIL-FIRED TUNNEL KILN.—A new tunnel kiln, 325 ft. long, has been put to work at the Napton Works, near Rugby, of the Allied Brick and Tile Co., Ltd. The kiln, which is of American design and British manufacture, is oil fired, and can produce 6-in. square flooring quarries at the rate of 29,000 a day. It replaces eight old-type coal-fired kilns.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SHORTAGE OF CEMENT IN SOUTH WALES.—In order to overcome the shortage of cement which is affecting the housing plans at Cardiff, Newport and Cwmbran, supplies from Belgium are being imported. Mr. Peter Freeman, M.P. for Newport, has complained, in the House of Commons, that a firm in Newport making concrete blocks for housing was only working half time because of the shortage. Mr. David Eccles, Minister of Works, has replied that the high level of building activity in South Wales had caused some delay in the delivery of bricks and cement blocks, but output was rising.

CARDIFF WATER SUPPLIES.—The Cardiff Corporation Waterworks Committee which are awaiting the result of a Ministry of Housing and Local Government inquiry into their application for powers to construct a new reservoir at a cost of over 900,000*l.*, at Blaen Taf in the Brecon Beacons, have decided to hold a special meeting to consider reports on the financial aspect of the scheme. The new reservoir would supplement the three existing Cardiff Corporation reservoirs in the Beacons. Mr. George W. Cover, the city water engineer and manager, told a meeting of the committee that the demand had risen so much since the last major works were completed that risks were being run with the supply during periods of dry weather. It is also announced that the Cardiff Corporation propose to construct a reservoir on part of a Glamorgan county smallholding at Radyr Court. The site, Mr. A. E. Dunkley, county land agent, told a meeting of the Glamorgan Smallholdings Committee, would occupy nearly three acres.

WELSH COAL OUTPUT.—Coal output in South Wales was at the highest point of the year in the week ended May 16 last. Production was 504,607 tons, compared with 489,370 tons in the previous week and 500,249 tons in the week which provided the Whitsun-holiday pay day last year.

DRIFT MINE AT TYMAWR COLLIERY.—A scheme for a new drift mine at Tymawr Colliery, Hopkinstown, was outlined to a meeting of Pontypridd Parks Committee by Mr. J. H. Pedley, the No. 3 area production manager of the South Western Division of the National Coal Board. He told the committee that it was hoped that the drift would yield from 800 to 1,000 tons of coal a day and greatly prolong the life of the colliery.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

CHEMICAL SOCIETY.—Thursday, June 4, 7.30 p.m., Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Meeting to commemorate the present-day aspects of the work of Sir William Ramsay. (i) "The Work of Sir William Ramsay in Relation to Nuclear Science and Technology," by Mr. J. S. Anderson; (ii) "Recent Results of Researches on the Composition of the Stratosphere," by Mr. F. A. Paneth; (iii) "Modern Light Sources," by Mr. H. G. Jenkins; (iv) "Industrial Applications of the Rare Gases in Metallurgy," by Mr. L. C. Bannister; and (v) "The Use of Helium in Diving," by Mr. H. J. Taylor.

ROYAL SANITARY INSTITUTE.—Friday, June 5, 10 a.m., Queen's Hall, Market-street, Wigan. Various papers, including "The Changing Pattern of Refuse Disposal and Its Effect on Vehicle Design," by Mr. Clive Walker.

ROYAL INSTITUTION.—Friday, June 5, 9 p.m., 21, Albemarle-street, W.1. "Glaciers," by Dr. M. F. Perutz.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Saturday, June 6, 7 p.m., George Hotel, Stoke-on-Trent. Annual General Meeting.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, June 9, 5.30 p.m., Great George-street, Westminster, S.W.1. Annual General Meeting.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, June 9, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Thermal Insulation of Plant and Buildings," by Mr. C. G. Bower. *Manchester Branch:* Tuesday, June 9, 7.15 p.m., Engineers' Club, Albert-square, Manchester. "Combustion Heat and Power," by Mr. C. F. Roberts. *Newcastle-upon-Tyne Branch:* Thursday, June 11, 7.30 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "The Plant Engineer and the Factories Act," by Mr. A. Hewitt. *Merseyside and North Wales Branch:* Monday, June 15, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Industrial Smoke Abatement," by Mr. P. H. Saunders. *Hertfordshire Discussion Group:* Tuesday, June 16, 7.30 p.m., Peahen Hotel, St. Albans. Discussion on "Dust Extraction."

ROYAL AERONAUTICAL SOCIETY.—Thursday, June 11, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. Ninth British Commonwealth and Empire Lecture on "Some Problems in the Development of Air Transport in West Africa," by Sir Hubert Walker.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 17, 5 p.m., 49, Cromwell-road, South Kensington, S.W.7. (i) "A Quantitative Analysis of Large-Scale Patterns, with Special Regard to the Effect of Eddy Motion," by Mr. F. A. Berson; and (ii) "On the Theory of Large-Scale Disturbances in a Two-Dimensional Baroclinic Equivalent of the Atmosphere," by Mr. P. D. Thompson.

ROYAL SOCIETY.—Thursday, June 18, 4.30 p.m., Royal Society's Apartments, Burlington House, Piccadilly, W.1. (i) "The Application of the Principles of Physical Optics to Crystal-Structure Determination," by Mr. A. W. Hanson, Mr. H. Lipson, and Mr. C. A. Taylor; and (ii) "Photo-Ionisation and the Breakdown of Gases," by Mr. J. Dutton, Mr. S. C. Haydon, Mr. F. Llewellyn Jones and Mr. P. M. Davidson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section:* Thursday, June 25, 7.30 p.m., Star and Garter Royal Hotel, Victoria-street, Wolverhampton. "British Watch and Clock Production," by Mr. R. Lenoir.

INDUSTRIAL OPPORTUNITY IN CANADA.—"Canada, a land of opportunity and a great market for British merchandise" is the message of a brochure issued by the Canadian Pacific Railway Company from its London offices, Trafalgar-square, W.C.2. The brochure points out that Canada is geographically larger than the United States, yet has a population not exceeding that of the Greater London area; the distances between the large cities of Canada are, therefore, immense, and over the 3,500 miles of territory requirements are not uniform. It is stated that British goods enjoy a high prestige for quality, and Canadians give them preference, provided the style and price suit the ideas of the moment, and if they conform to Canadian conditions. Unfortunately, however, there has been a tendency on the part of British manufacturers to ignore Canadian tastes, which has resulted in some loss of goodwill. The brochure gives information on the best way to tackle the Canadian market and gives hints on the setting up of agencies, advertising, and the like, and concludes with an invitation to make use of the services of the company's Department of Industrial Development.

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 24, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Copper Sheet and Strip for Electrical Purposes.—A revised edition of B.S. No. 1432, dealing with copper sheet and strip for electrical purposes, has now been published. It constitutes one of a series of specifications for copper for electrical purposes, the others being B.S. No. 1433, covering bar and rod, and B.S. No. 1434, relating to commutator bars. A further specification, which will be concerned with tubes, is shortly to be published. The principal feature of the revision of B.S. No. 1432, which includes provisions for annealed, half-hard and hard conditions, is the introduction of two tabular diagrams of recommended sizes of annealed sheet and strip for transformer windings and the windings of rotating electrical machinery. From these, designers are encouraged to choose their requirements. It is hoped that, in this manner, there will be, in time, a considerable reduction in the number of sizes demanded. An additional provision is to the effect that a purchaser can, by special arrangement, specify that sheet or strip shall be made from oxygen-die high-conductivity copper, complying with the recently-published specification, B.S. No. 1861. [Price 4*s.*, postage included.]

Metal Containers.—Latterly, considerable progress has been made towards the completion of B.S. No. 1133, a publication entitled "Packaging Code." Two large sections have recently been issued and the Institution has now published a revised edition of section 10 of the Code, covering metal containers. Thus, 13 of the projected 20 sections are now available and two further sections are likely to be issued shortly. The new edition of section 10 has five sub-sections. The first gives details of the materials and construction of tins and cans and the second describes the materials for, and the construction of, metal drums. The third sub-section is concerned with metal crates, hampers and trays, the fourth with collapsible tubes and the fifth with composite containers. The publication is well illustrated and there are definitions of many trade terms. [Price 10s., postage included.]

Oil-Burning Equipment.—A first revision of B.S. No. 799, which deals with oil-burning equipment, has now been made available. The publication was originally issued in 1938 and was then confined to fully-automatic oil-burning equipment for central heating and hot-water supply, suitable for fuel oils conforming to grades "A" and "B" of specification B.S. No. 742, covering fuel oils for burners. The specification has now been extended to include semi-automatic and hand-controlled equipment suitable for petroleum oils, grades "A," "B" and "G" of B.S. No. 742, and the coal-tar liquid fuels specified in B.S. No. 1469. The specification applies to oil-burning equipment for boilers, heaters, furnaces, ovens and similar plant, but it is not intended to apply to marine and mobile installations. [Price 10s.]

Keys and Keyways.—Since the specification for keys and keyways, B.S. No. 46, was first published in 1909, it has been revised and brought up to date three times. The third revision of the specification known since 1924 as B.S. No. 46: Part 1, embodies the results of long and painstaking investigations into the general run of modern practice. Hence, several features, familiar in the previous edition of April, 1929, have been omitted and others are presented in new guise. Probably the most important change is in the table of Woodruff-key dimensions which has been brought into line with American practice, in that the numbers for the keys and the keyway cutters are now identical and give information on the nominal dimensions of the key. The tolerances on the dimensions of keys and keyways for the ordinary type of rectangular and square, parallel and taper, plain and gib-head series, include moreover, a minimum hand-fitting allowance. [Price 5*s.*]

Thermosetting Synthetic-Resin Bonded-Paper Round Tubes for Use at Radio Frequencies.—A new specification, B.S. No. 1951, stipulates the requirements of two grades of synthetic-resin bonded-paper tubes of circular cross-section for use at radio frequencies, and in this respect is complementary to B.S. No. 1314 and B.S. No. 1885, which cover, respectively, circular and rectangular cross-sectioned synthetic-resin bonded-paper tubes for electrical power circuits. In the new publication, the requirements for the tubes up to 1 in. external diameter are specified and the electrical and physical properties covered include power factor and permitivity; insulation resistance along laminæ; density; water absorption; cohesive strength between layers, and dimensional tolerances. [Price 2*s.* 6*d.*]

PERSONAL.

MR. P. CROOM-JOHNSON, C.B.E., M.I.C.E., chief engineer to the London Transport Executive, 55, Broadway, London, S.W.1, retires on June 20, after more than 40 years in the engineering profession.

MR. G. W. H. GARDNER, C.B.E., has been appointed director general of technical development (Air), Ministry of Supply, in succession to MR. S. SCOTT HALL, C.B., as from June 5.

MR. ALONZO LIMB, managing director of C. C. Wakefield & Co. Ltd., 46, Grosvenor-street, London, W.1, has been elected to the additional post of deputy chairman. The chairman is MR. L. W. FARROW, C.B.E.

BRIGADIER L. N. TYLER, O.B.E., Deputy Director of Mechanical Engineering, War Office, is to become Director of Mechanical Engineering, Middle East Land Forces, with the rank of Major-General, with effect from September next. BRIGADIER R. B. STOCKDALE, O.B.E., officer commanding 22nd heavy workshop, British Army of the Rhine, was made Deputy Director of Mechanical Engineering, Southern Command, as from February 26. COLONEL D. A. K. REDMAN, O.B.E., Deputy Director of Mechanical Engineering, 1st Corps, B.A.O.R., is to be Deputy Director of Mechanical Engineering, War Office, with the rank of Brigadier, with effect from July next. COLONEL C. R. L. HOPPER, O.B.E., officer commanding 31st base workshop, has been made, this month, commandant, base workshop group, with the rank of Brigadier.

MR. JOHN ALCOCK, chairman and managing director of the Hunslet Engine Co. Ltd., Leeds, 10, has been elected President of the Locomotive Manufacturers Association.

MR. W. HAWKINS, chief erection and service engineer to Spencer-Bonecourt Ltd., has retired after 33 years of service with the company.

MR. R. E. DAWTREY has been appointed chief engineer to Sheepbridge Engineering Ltd., Chesterfield, and will be responsible for all metallurgical, chemical and engineering research and development.

MR. A. W. DANIELS, M.I.Mech.E., has announced that he is relinquishing his office of director of B.V.C. Industrial Construction Ltd., Terminal House, 52, Grosvenor-gardens, S.W.1. He will terminate his association with the company as from May 31.

MR. F. A. VAUGHAN has been appointed managing director of Brush ABOE (Southern Africa), Ltd., Johannesburg, in succession to MR. MICHAEL CLEAR, B.Sc., M.I.Mech.E., who, as stated on page 655, *ante*, has been appointed group sales director of the Brush Group of Companies.

MR. HAROLD FLAVELL, chief buyer of Herbert Morris, Ltd., Loughborough, has been elected a director.

MR. C. J. TEASDEL has resigned his appointment with Crompton Parkinson Ltd., to join the board of M.T.E. Control Gear Ltd., Leigh-on-Sea, Essex, as sales director.

MR. F. C. HALLAWELL has been appointed manager of the Metropolitan-Vickers Electrical Export Co. Ltd. Trafford Park, Manchester, 17, for Brazil, in succession to MR. H. W. FOY, who continues in an advisory capacity. MR. E. E. SARASA, A.M.I.E.E., is to be the firm's manager for Argentina, and MR. R. MORRIS, D.F.H., A.M.I.E.E., technical representative in Colombia, Peru and Venezuela.

MR. W. E. THOMPSON, secretary of Laycock Engineering Ltd., Archer-road, Sheffield, has been appointed a director of the company. MR. KENNETH WALKER, A.M.I.Mech.E., A.M.I.P.E., assistant production engineer, has been appointed works director.

MR. L. PEMBERTON has been made chief technical representative of Sanders and Forster Ltd., Thames Works, Hertford-road, Barking, Essex.

PROABD (ENGLAND) LTD., Wheatsheaf House, Carmelite-street, London, E.C.4, a recently formed British chemical-engineering organisation designing and making plant for the distillation of tar, and other equipment, have technical liaison with the SOCIÉTÉ PROABD, of Nancy, France. The manager is MR. A. F. PEART.

THE CONSOLIDATED PNEUMATIC TOOL CO. LTD., 232, Dawes-road, London, S.W.6, inform us that a new company, the CONSOLIDATED PNEUMATIC TOOL Co. S.p.A., Viale Piceno N.19, Milan, Italy, has been formed.

FLEXIBOX LTD., Nash-road, Trafford Park, Manchester, 17, and the SEALOL CORPORATION, Providence, Rhode Island, U.S.A., have concluded two agreements whereby the latter firm has an exclusive licence to manufacture and sell Flexibox mechanical seals in the United States and Canada and Flexibox Ltd. have the exclusive rights to manufacture and sell Sealol seals in the British Isles and many European countries.

PICKERINGS LTD., Globe Elevator Works, Stockton-on-Tees, have removed their Scottish office to 66-70, McCulloch-street, Glasgow, S.1. (The telephone number: Glasgow, South, 1884, remains unchanged.)

CRAWLEY FOUNDRY AND FACTORY OF THE A.P.V. CO., LTD.

(*For Description, see Page 673.*)

FIG. 2. ALUMINIUM AND COPPER-BASE ALLOY FOUNDRY.

FIG. 3. STAINLESS-STEEL FOUNDRY.

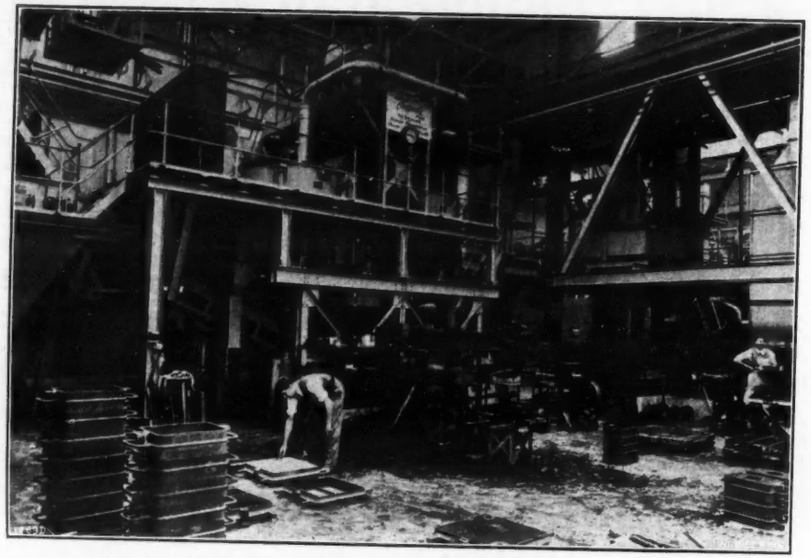


FIG. 4. ALUMINIUM AND BRONZE FOUNDRY: SAND-TREATMENT PLANT.

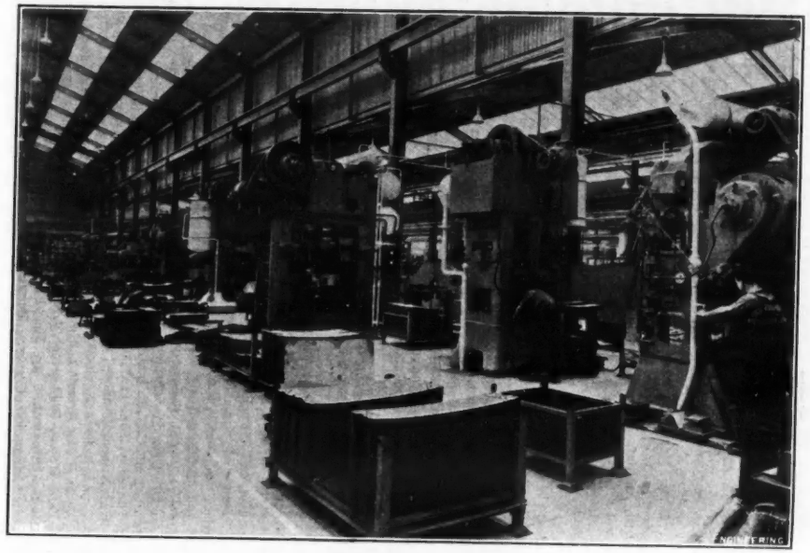


FIG. 5. PRESS SHOP IN FACTORY.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

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SUBSCRIPTIONS.

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For Canada	£5 5 0

Subscriptions for periods less than twelve months are based on the price of a single copy, namely, 2*s.* 3*d.* post free.

ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, MAY 29, 1953.

VOL. 175. No. 4557.

THOUGHTS ON THE CORONATION.

THE relentless demands of modern life are suppressed for a while to make room in the hearts and minds of men for the glory of the Coronation. Miraculously, the Royal and religious occasion evokes a response from the people surpassing that due to any other contemporary event, and many a man is thankful that there is still this one expression of national feeling at once historical enough, hopeful enough and deep enough to transcend the mesmerising power of current affairs.

The rejoicing of the Commonwealth—shared, in some degree, by other nations—is not only an acknowledgment of the power for good of the British Monarchy but also a sign of a spiritual side of human nature that Twentieth Century civilisation does little to satisfy. A foreign observer would be mistaken if he regarded the Coronation solely as a symbol of national strength and solidarity; it is this and more. To the peoples of the Commonwealth it is an enduring anchor in a changing world. How admirable, therefore, that a small part of the year's toil and effort should be devoted to preparations for the Coronation of Her Gracious Majesty Queen Elizabeth II. Since the time before her accession to the Throne (the photograph which decorates our front cover this week was taken before her accession), her subjects have become happily aware of her unique fitness to lead them. The set-backs which the Monarchy has suffered in history have served only to strengthen its hold, so that now it is something supremely above politics; indeed, it is in a different realm of significance. Politics aims at the ideal but, inevitably, it falls short; and it always will fall short. But the Royal family is a living expression of the ideal—admired, respected, commanding the allegiance of all.

Other institutions and influences of national life are seen to be correspondingly less than ideal. In the modern era, there have been times when science and engineering seemed to hold the key to an ordered, universal prosperity; the basic needs of men and women would easily be met, and there would be ample wealth to provide for the luxuries of civilised life. But it has turned out differently. Quite apart from war and the effects of war, the world is a relative world: a labourer's family may have a higher standard of living than their ancestors two centuries ago, but if they are relatively poor to-day they are, simply, poor. Similarly with nations: it is difficult to know how the standards of living of all nations can be raised to more or less the same level, and it is harder still to visualise the result of failing to achieve such an ideal.

Men of science and engineering may, for this reason, ponder the ultimate purpose of their work. If a long-term view is to be rejected, on the grounds, already stated, that nations will always differ in respect of wealth, influence and technological development, can it be said that men are any better, here and now, for having the great sources of power in Nature directed for their use and convenience? Better off they certainly are; but happier, more humane, more civilised? Disraeli said that "The European talks of progress because, by an ingenious application of some scientific acquirements, he has established a society which has mistaken comfort for civilisation." Certainly the bright light of scientific progress has blinded men to the enduring values in life, but there are signs that it is only a temporary blindness. Though the undeveloped countries of the world are looking to science to save them from economic backwardness (and are fascinated by the glittering future it seems to promise), in this country, if not also in Europe and the United States, men are regaining the ability to observe Disraeli's distinction between comfort and civilisation.

Paradoxically, many scientists in the history of the world have themselves been conscious of the distinction. Mr. Charles Morgan expresses it thus: "None can say to what end man was brought into the world, nor what the destiny of the race may be, yet there are great spirits who live not for their present ease but in quest of an impersonal end, as though a runner should spend himself in a relay-race for an unknown, and by him unattainable, prize. Leonardo was such a man, and who gives life for her child is such a woman. The distinction is not of talent but of spiritual genius and racial faith. The humblest may have it, the giants of power and intellect be without it. It is not definable in any person, for it is not a personal possession; its nature is to be continuous, like the handing on of a torch. Its convenient name is the Spirit of Man, and the proof of its existence that, under that name, all men recognise it."

Science, then, is neutral. It is part of the matrix of life; altering it profoundly, changing the environment more in a generation than in the whole of history, but not changing in any way the ethical nature of man. It is well to remember this; not for the purpose of retarding the progress of science, but to enable us to see science in due proportion. For this reason the Coronation is a blessing. Men's hearts and minds are directed anew, and a short-sighted focus on immediate problems gives way to a deeper philosophy of living and working. The Coronation of Queen Elizabeth II bids men to look forward with a surge of hope engendered by the young Queen, bearing that illustrious name, and links them with the best in the nation's history.

FIG. 5. PRESS SHOP IN FACTORY.

FIG. 4. ALUMINIUM AND BRONZE FOUNDRY; SAND-TREATMENT PLANT.

NOTES.

THE IRON AND STEEL BOARD.

SPEAKING in the House of Commons on May 21, Mr. Duncan Sandys, Minister of Supply, said that, in accordance with the provisions of the Iron and Steel Act, 1953, he had appointed 11 members of the Iron and Steel Board, leaving four places which could be filled if this should be found desirable in the light of the Board's experience. The three whole-time members who had agreed to serve were Sir Archibald Forbes, who was to be the independent chairman of the Board; Sir Lincoln Evans, C.B.E., the vice-chairman; and Mr. Robert M. Shone, C.B.E., M.Eng. As it would not be appropriate for a whole-time member of the Board to hold any other appointment connected with the iron and steel industry, Sir Lincoln Evans had arranged to relinquish his position as general secretary of the Iron and Steel Trades Confederation. Similarly, Mr. R. M. Shone's appointment as director of the British Iron and Steel Federation had been terminated. The eight part-time members of the Board comprised Sir Andrew McCance, D.Sc., F.R.S., managing director of Colvilles Ltd.; Mr. Neville H. Rollason, managing director of John Summers & Sons, Ltd.; Mr. James Owen, general secretary of the National Union of Blastfurnacemen; Mr. Wilfred Beard, general secretary of the United Patternmakers' Association; Mr. James Shaw, chairman of Allied Ironfounders, Ltd.; Mr. Charles Connell, President of the Shipbuilding Conference; Sir Percy Lister, chairman of R. A. Lister & Co., Ltd.; and Mr. G. E. Beharrell, managing director of the Dunlop Rubber Co., Ltd. The chairman of the Board would receive a salary of 7,500*l.*, the whole-time members 5,000*l.*, and the part-time members, 1,000*l.* It was announced last week-end that Mr. Beard had resigned from the Board on May 23. That same evening, Mr. Sandys stated that Mr. Andrew Naesmith, C.B.E., general secretary of the Amalgamated Weavers' Union, had accepted his invitation to join the Board as a part-time member, in place of Mr. Beard.

BRITISH RAILWAYS IMPROVEMENT SCHEMES.

It is announced that British Railways have been authorised by the British Transport Commission to proceed with three major improvement schemes at a total cost of nearly 4*l.* million. The first of these involves the construction of two additional tracks on the east-coast main line between Greenwood signal box (north of New Barnet station) and Potters Bar station. Here they will link up with the widening and reconstruction at Potters Bar station itself, which has already been authorised. To do this, it will be necessary to carry out 1,830 yards of new tunnelling, as well as to reconstruct Hadley Wood station. Colour-light signalling, with the necessary track circuiting, will also be installed. The present double track carries some 300 to 350 trains per day, and the provision of an additional line in each direction will, it is hoped, overcome the delays which now frequently occur. Work is expected to start in the early part of 1954, and will take five years to complete. The Crewe North motive power depot on the main line from Euston is also to be modernised. At the present time, between 120 and 150 locomotives are stationed at this depot, the efficient maintenance of which is hampered by the closeness of the tracks. To overcome this, a new examination and repair building, in which 16 steam and two Diesel shunting locomotives can be accommodated, is to be erected south of the station; a locomotive shed of the roundhouse type with 32 roads is to be constructed round an existing 70-ft. turntable at Crewe North; and a second roundhouse and 70-ft. turntable is to be built at the same place. These roundhouses will provide space for 58 locomotives to be stabled simultaneously. In addition, coaling and ash plants are to be constructed, and fluorescent lighting installed in the locomotive inspection and repair pits, while office and staff accommodation will be provided. The total cost of this modernisation will be about 1*l.* million. A similar sum will be spent on the erection of a motive-power depot at Thornaby, near Middlesbrough, to deal with the additional traffic caused by the expansion of the iron, steel and chemical industries on Tees-side. This depot will initially be equipped with two roundhouses, each of which will contain a 70-ft. turntable. There will also be shops for the repair of steam locomotives and the maintenance of Diesel-electric locomotives, as well as inspection and ash pits, a 350-ton coaling plant, and office accommodation. Alterations to the rail connections to the Newport marshalling yards will be made to facilitate the routing of locomotives to and from the new depot, and colour-light signalling and track circuits will be installed between Thornaby East and Newport East signal boxes.

THE INSTITUTION OF ENGINEERS-IN-CHARGE.

The Institution of Engineers-in-Charge held their 48th annual dinner at the Holborn Restaurant, London, on Friday, May 15, under the chairmanship of their President, Sir William A. Stanier, F.R.S., M.I.Mech.E. A total of 164 members and their guests attended. In proposing the toast of "The Institution," Sir Harold Roxbee Cox, Chief Scientist, Ministry of Fuel, suggested that there existed a danger of industrial complacency; he admitted that there were signs of increased productivity and of slightly lower costs but, he continued, it would be necessary to produce some new products before claiming that any real progress had been made. In his response, the President said that the Institution, holding regular meetings at which papers were submitted for discussion, provided a forum for widening knowledge, particularly to the benefit of the younger members who were still in the process of completing their training. Sir William ended his remarks by acknowledging the enthusiasm of the officers of the Institution and by thanking them for the help they had given him during his year of office. The toast of "The Guests" was proposed by the immediate past-president of the Institution, Mr. Robert Chalmers, O.B.E. In reply, Dr. S. Livingston Smith, C.B.E., Director of Research, British Shipbuilding Research Association, commented on the excellent form of the Institution's name: "Engineers-in-Charge," Dr. Livingston Smith suggested, could be the solution to many of the world's problems.

EDUCATION IN CHEMICAL ENGINEERING.

In the recurrent discussions about the relations of the universities to industry much attention has of late been paid to the question of the industrial employment of arts graduates. The engineering industry, which was a pioneer in the operation of graduate-training schemes, has naturally concerned itself in the main with science graduates. The example which it set is now being extensively followed by manufacturing and other businesses of a non-engineering type, arts graduates being accepted for training in administrative and commercial duties. It is interesting to learn that an example was set by the Shell Petroleum Company as long as forty years ago, a number of arts graduates being trained to fill a proportion of the vacancies for non-technical staff. The business of the Shell Company is, however, of a highly-technical nature and it is natural that, in the main, its training and educational activities should be directed towards technical and scientific ends. Many engineering companies have extensive foreign connections and accept students from many countries for graduate training, but there can be but few organisations which operate in more than fifty countries. The Royal Dutch-Shell Group of oil companies is one of these and this wide sphere of activity has called for broad views in its educational policy. Grants have been made for the training of students from Australia, New Zealand, South Africa, India, Pakistan, and various South American and Eastern countries. The annual expenditure for educational purposes is now some 275,000*l.* per year. This covers scholarships, grants to universities and for post-graduate research. This expenditure is apart from donations made over the last ten years or so. The largest of these was the sum of 435,000*l.* for the endowment of a Chair of Chemical Engineering at Cambridge, but many other universities and colleges have been similarly assisted, notably University College, London; the Royal Technical College, Glasgow; and the School of Geology, Oxford.

INCORPORATED PLANT ENGINEERS.

The Incorporated Plant Engineers held their sixth annual conference at the Palace Hotel, Southport, from May 20 to 22. On May 20 the branch secretaries held a conference, and in the evening a Civic Reception and Ball was given at the Floral Hall by His Worship the Mayor of Southport, Alderman W. Tattersal, J.P. On May 21 the annual general meeting took place and Mr. J. C. Veale, M.Eng., A.M.I.Mech.E., succeeded Mr. G. A. Rooley, A.M.I.Mech.E., as President. The technical session opened with a paper by Mr. E. J. Parish, director and general works manager of the Renold and Coventry Chain Company, on "Management and the Plant Engineer." During the afternoon, Dr. C. B. Davies, M.A., manager of the Thornton Research Station of the Shell Petroleum Company, gave a paper entitled "The Lubrication of Engines and Industrial Equipment" and in the evening the conference split into four groups for discussions on the following subjects: "The Plant Maintenance Productivity Report," led by Mr. Colin Troup, B.Sc.; "The Plant Engineer and Costs," led by Mr. E. C. Stevens, M.A., B.Sc.; "Keeping Abreast of the Times," led by Mr. T. Bradshaw, and "Formwork for Concrete Construction," led by Mr. W. Morton Jones. Later there was a dinner, the President taking the chair. The toast of the County Borough of Stockport was proposed by Mr. G. A. Rooley, the past-president, and responded to by His Worship the Mayor. The principal guest, Sir Raymond Streat, C.B.E., chairman of the Cotton Board, proposed the toast of the Institution and expressed the view that more conferences of this nature were required to produce a full interchange of ideas. Such conferences, he said, helped in the search for efficiency and the ever increasing tempo of modern industry. He considered that the conference was a form of vocational training for modern industry and that top-level management should give full recognition and encouragement to bodies such as the Incorporated Plant Engineers, because such recognition could, he thought, help a great deal in the present drive for an increase of industrial efficiency. The President replied to the toast. Mr. D. Lacy-Hulbert, B.Sc., a past-president, proposed the toast of the guests, and Professor Wright Baker, Professor of Mechanical Engineering, University of Manchester, responded. On Friday, the presentation of the Alexander Duckham Memorial Awards took place and was followed by short discussions on the prize-winning papers. Mr. G. E. Halter presented his paper "Heat Exchanger Maintenance and Reconditioning," which won the Silver Medal, and Mr. G. W. Campbell, who won the Bronze Medal, gave his paper on "Transportation."

ROAD MAINTENANCE.

In the conclusions to the fifth report of the House of Commons Select Committee on Estimates, it is stated that no convincing evidence was submitted to the Select Committee to show that the roads have so far deteriorated, as a result of restrictions in expenditure on maintenance, as to be an appreciable danger to users, or that their value as a national asset is seriously threatened. The report, which contains a verbatim transcription of the verbal evidence, shows that the County Councils' Association, the British Road Federation, and the standing joint committee of the R.A.C., A.A., and the R.S.A.C. did, in fact, submit such evidence, but opposing submissions were made by the Association of Municipal Corporations and by the Chief Engineer of the Ministry of Transport. The Committee admitted in their conclusions that there

had been difficulties in arriving at a wholly reliable judgment on the evidence that had been put before them. Their terms of reference required them to report what, if any, economies could be made in the costs of road maintenance. No such recommendations were made, it being generally agreed that, whatever the sum made available from the national Exchequer, it could be used to benefit the condition of the roads. It was stated in evidence that, at the present time, about 70 per cent. of all goods were carried by road transport and, it has been estimated elsewhere, that about 10 per cent. of the national expenditure was directly or indirectly concerned with road transport. Deterioration of the roads, which must occur if maintenance was inadequate, was therefore recognised as being a significant factor in national economy. The committee recommended, therefore, that the procedure for framing the road estimates should be re-examined with the aim of devising some method which would furnish the Ministry of Transport with a more precise picture of the condition and the needs of the roads for which the State is asked to provide. The Committee also called for evidence of the work of the Road Research Laboratory of the Department of Industrial and Scientific Research, and recommended that improved means should be found of disseminating the results of the work of the Laboratory.

BRITISH GEAR MANUFACTURERS' ASSOCIATION.

The 9th annual general meeting of the British Gear Manufacturers' Association was held at the Piccadilly Hotel, London, W.1, on Tuesday, May 19. Prior to the luncheon there was a discussion on gear shaving and gear grinding. Mr. A. Sykes, B.Sc. (Eng.), Wh.Ex., M.I.Mech.E., chairman of the British Gear Manufacturers' Association, opened the discussion on the former subject, and Mr. A. H. Orcutt spoke on gear grinding. It is hoped to give a review of the first paper in a later issue of ENGINEERING. A discussion followed and had to be brought to an end sooner than many wished. Mention was made of trends in the United States and it was claimed that gear manufacturers in that country were now turning more than ever towards gear grinding. The general feeling here, however, appeared to indicate that shaving and grinding each have their own special fields of application and that this would be the position for some time to come. Rear-Admiral (E) A. D. McGlashan, D.S.O., M.I.Mech.E., R.N., of the Naval Ordnance Department, Bath, proposed the toast of the Association, following the luncheon, and he mentioned some of the equipment using gears in which he and the Admiralty were interested. Anti-aircraft guns, and servo mechanism, etc., he thought, were only as good as the gears that controlled them; a very high standard was required. With an anti-aircraft gun, he said, the problem was to direct a shell accurately over 20,000 yards. Some 100 gears assisted in this task; thirty of them needed to be to the Admiralty's specification Class I, 55 to Class II, 10 to Class III, corresponding to instrument gear standards, and five to Class VI, an ordinary commercial requirement which was the lowest standard accepted by his department. He thought that the British Standard Specification for gears was certainly too low. He mentioned the cost of high-class gears and hoped that it might be reduced. He thought that the D.S.I.R. could, and would, do a lot to encourage improvements and that there was a need for more machines capable of producing high-class gears. He ended his remarks with the suggestion that there was a need for a guide to show how gears were made. Mr. Sykes, who replied for the Association, thanked Rear-Admiral A. D. McGlashan and said that he disagreed with the Admiralty Specification. He went on to say that the B.M.G.A. was an association unfettered by restrictive practices. They were interested in research, and the collection and dissemination of information for the general use, and were also ready for keen and healthy competition. Mr. E. Liebert proposed the toast of the guests and Dr. T. W. F. Brown, M.I.Mech.E., M.I.N.A., Research Director of the Parsons and Marine Engineering Turbine Research and Development Association, replied.

OBITUARY.

MR. W. SYMES.

WE regret to record the death of Mr. W. Symes, manufacturing consultant to Associated Electrical Industries, Limited, which occurred on Monday, May 18.

Walter Symes began his professional career with the British Thomson-Houston Company at Rugby, but in 1914 joined the British Westinghouse Electrical Manufacturing Company (now the Metropolitan-Vickers Electrical Company), where for six years he was employed in the design of electrical equipment. In 1920, he became engaged in pioneer work on time and motion studies and was appointed assistant superintendent in the Company's Process and Rate Department. Three years later he turned to the manufacturing side and successively held the positions of assistant superintendent and superintendent of the Detail Department, as well as being superintendent of the Transformer Department. As superintendent of the Detail Department he was responsible for a wide range of products, including switchgear, traction and railway signalling apparatus. His responsibilities were greatly increased in 1936 when the first contract under the Defence Programme was obtained and the Trafford Park works were extended to provide space for the manufacture of searchlights, sound locators and gun mountings. Two years later, work on radar transmitters was begun, necessitating a further extension of factory space and the installation of much manufacturing and testing equipment, for all of which he was responsible.

In 1944, Mr. Symes was appointed works manager at Trafford Park and during the eight years he held that position he planned a number of extensions to the Metropolitan-Vickers factories, which amounted in all to over 1,000,000 sq. ft. of covered floor space. He became a director of the company in 1948 and joined Associated Electrical Industries, Limited, as manufacturing consultant in 1952, a position he was still holding at the time of his death.

TRANSPORT COMMISSION'S COLLECTION OF ROAD, RAIL AND SEA RELICS.

THE British Transport Commission early resolved to collect and preserve all that they reasonably could of those historical records and relics of transport in which this country abounds. The first outward expression of their resolution is an exhibition, "London on Wheels," which is now open to the public in the celebrated Shareholders' Meeting Room at Euston Station. The approach to the room is up the familiar wide staircase behind the statue of George Stephenson in the Grand Hall.

The exhibition is of travel—by water as well as road and rail—in and around London during the Nineteenth Century. There are models of hansom cabs, horse buses and horse trams, Thames steamers, and railway locomotives, carriages and signals, in addition to full-size replicas of a Midland Railway third-class compartment of 1875 and a section of a Pullman dining car of about 1895. Among the relics are early railway tickets, hand-bills and posters, railway-police handcuffs, oil lanterns and truncheons, and a pistol and blunderbuss of the kind issued to guards on mail coaches for the protection of Royal mails. The excellence of the service provided by the railways as early as 1838 is recalled by a hand-bill of the London and Birmingham Railway, dealing with the rates for conveying carriages and horses between the two cities: "N.B. Gentlemen's Carriages and Horses must be at the Station at least a Quarter of an Hour before the time of Departure." The gentlemen are reminded that a supply of trucks is kept at the principal stations, but to prevent disappointment it is recommended that previous notice be given.

The Shareholders' Meeting Room was opened by the London and North Western Railway in 1849, and is thought to be the only room built specially for general meetings of railway shareholders. Its decorations have been restored to conform with the original specifications of the architect, and, along with the exhibition show-cases (which are expertly designed and arranged), it presents a most tasteful appearance. The exhibition has been arranged under the direction of Mr. John Scholes, A.M.A., curator of historical relics, British Transport Commission, and will be open daily until August 29 (weekdays, 10 a.m. to 7 p.m.; Sundays, 2 p.m. to 7 p.m.). An illustrated brochure entitled "London on Wheels" is on sale (price 1s.); it has been written by Mr. Hamilton Ellis, with the collaboration of Mr. H. G. Davis, assistant to the curator. It is, however, a historical essay, not a catalogue of the exhibits.

Opening the exhibition on May 20, Lord Hurcomb, chairman of the Commission, said that the Historical Records Section had now registered no less than 10,000 objects. The documents and files, he said, were increasingly used by students and research workers. The aim was that the collection should live and grow, and owners of private collections who wished to forestall the dispersion of their treasures would find proof in this first public exhibition that the Commission were alive to their responsibilities as public custodians. He hoped that this view would be shared by retired members of the staffs of the former companies in many parts of the country, who, during their active service, had rescued and preserved objects which, but for their personal intervention, might have been destroyed or lost. At this time, when people's minds were occupied with the Coronation, the Commission were arranging an exhibition of some of the elegant railway carriages in which our Kings and Queens travelled in the last century. The exhibition would be open to the public next month at Battersea Wharf station, by Chelsea Bridge.

Referring to historic locomotives, Lord Hurcomb said that some which were due to be broken up were being retained provisionally so that a final choice could be made, having regard to the facilities for storage and display. To overcome the problem of filling gaps in the existing collection of locomotives, the Commission were giving favourable consideration to the recommendation that a series of scale models should be built. Nine Elms Station could not at present be used as a British Transport Museum in London, but he hoped it would be possible to find a building suitable for holding early road vehicles as well as locomotives. The Railway Museum at York would continue to concentrate on the history of railways in the North of England, and later they hoped to establish museums in London, in Scotland, and possibly elsewhere. In marine engineering the Commission could not attempt to cover the field, although they owned and operated a considerable fleet of sea-going ships. Last year, however, three outstanding examples of marine engineering from ships taken out of service—the T.S. King Edward and the T.S. Hantonia—had been preserved. They would be sent in a few weeks' time to the Clyde, where the ships had been designed and built, to be placed in the shipbuilding section of the Glasgow Museum.

AUTOMATIC VOLTAGE STABILISER.—The automatic stabiliser manufactured by Servomex Controls, Ltd., Crowborough Hill, Jarvis Brook, Sussex, is designed to maintain a constant output voltage between 200 and 240 volts indefinitely to within 1 per cent. and to give a maximum change of 0·2 per cent. with a frequency variation of 10 per cent. Monitoring of the output voltage is effected by a comparator circuit, which measures the error from the correct value. If this exceeds 1 per cent. it operates a variable auto-transformer, which restores the proper conditions at a maximum rate of 12 volts per second. The bandwidth, which determines the speed at which the mechanism can reverse, is 2½ cycles per second.

IMPROVEMENTS AT TILBURY DOCKS.—Approval was given by the Port of London Authority last week to a scheme for making extensive improvements on the north side of the main dock at Tilbury, in order to provide adequate accommodation there for the larger vessels of the Orient and P. and O. Lines. The work will be undertaken in two sections and it is expected that a commencement will be made shortly. One of the principal items included in the first stage will be the construction of a quay wall 843 ft. in length and having a return section 240 ft. long. New permanent-way, roads, a transit shed, and a covered passenger platform will form part of the work to be carried out in the second stage.

THE ROYAL SOCIETY'S CONVERSAZIONE.

THE annual conversazione of the Royal Society was held at Burlington House, London, W.1, on Thursday, May 21, when the Fellows and guests were received by the President, Dr. E. D. Adrian, O.M. As usual, there was a display of exhibits, but the majority of these were of a biological or chemical character. Engineering as such was hardly represented, and physics was not so prominent as is sometimes the case. It is not unworthy of note, as an indication of the way new techniques are being introduced into the field of pure science, that applications of germanium formed the basis of three exhibits and that electronic devices were increasingly prominent. Under-water cine-photography found a place in a film, which has been made under the auspices of the Marine Laboratory at Torry, Aberdeen, to investigate the seine net method of fishing and thus to discover the best method of preventing overfishing.

In his Presidential Address to the Institution of Electrical Engineers in 1950, Sir Archibald Gill foreshadowed the introduction of telephone exchanges in which the present switches with moving parts would be replaced by electronic devices. The progress which has been made in this direction was illustrated by the exhibit of the Post Office Engineering Department. This consisted of an embryonic exchange embodying time-division electronic switches for inter-connecting the lines. These switches enable calls to be set up by dialling in the usual way and the called line's bell then rings until it is answered, when the call is registered. The application of these devices is so far only exploratory, but their use would mean a reduction in the time of establishing a connection and more reliable service at possibly less cost.

Messrs. A. F. Gibson and R. Lawrence of the Telecommunications Establishment, Great Malvern, were showing an infra-red communication system in which a germanium modulator is employed. Transistor theory indicates that under suitable conditions the passage of an electric current through a germanium crystal increases the density of its free electrons. These electrons then give rise to increased optical absorption in the infra-red region. In the exhibit a germanium infra-red modulator was driven by a gramophone and used to vary the intensity of an infra-red beam derived from a tungsten lamp. The amplitude of the beam was thus modulated and detected by a lead sulphide photo-conductive cell, the output of which was, in turn, amplified and fed to a loud speaker. Apparatus exhibited by Messrs. G. B. B. Chaplin and F. C. Williams, of Manchester University, illustrated the use of transistors in electronic circuits of the type employed in radar and calculating machines, and indicated how this device could be utilised to replace thermionic valves owing to its compactness, low power consumption, long life and absence of warming up time. Messrs. E. G. James, D. J. Kyte and A. R. F. Plummer, of the General Electric Company's Research Laboratories, displayed the photo-conductivity effects that occur with germanium P.N. junctions and a new phenomenon which is associated with electron traps in silicon. When light falls on germanium, electrons are ejected from the valence bonds, leaving vacancies which are known as positive holes; and both the electrons and the holes diffuse away from the illuminated region. When a region near a P.N. junction is illuminated the saturation-reverse current is increased and gives rise to photo effects. Moreover, when pulses of very short duration are applied to a silicon point contact rectifier changes are produced in the current/voltage characteristic and pronounced current peaks occur at cut-in peak voltages. This phenomenon appears to be caused by electrons trapped in the lattice vacancies, the mechanism being similar to that occurring in photo-luminescence.

The Plastics Division of Imperial Chemical Industries, Limited, demonstrated high elasticity and frozen-in strain phenomena in Perspex. When Perspex is deformed by applying a stress, as in a long-term creep experiment or tension or compression test, it is found to exhibit what appears to be plastic (non-recoverable) flow. In reality, however, all such deformation is completely reversible as is shown by the fact that after heating the material returns to its original shape. That the material possesses this property was also shown by the fact that above a temperature of about 120 deg. C. Perspex behaves as rubber, and can be stretched several hundred per cent. without breaking. It can then be frozen in a strained state by cooling, although it returns to its original dimensions when re-heated.

A joint exhibit by Messrs. V. E. Cosslett and D. Jones, of the Cavendish Laboratory, Cambridge; Messrs. M. E. Haine and W. Hirst, of the Associated Electrical Industries Research Laboratory; and Mr. J. W. Menter, of the Physics and Chemistry of Surfaces Laboratory, Cambridge, was arranged to show how the relief of a solid surface can be studied by collecting the electrons scattered from it in the objective lens of an electron microscope. The best results, it was demonstrated, are obtained if the illuminating electron beam meets the surface at a grazing angle of a few degrees and when the collection angle is of the same order. The foreshortened image thus obtained shows the surface relief with great clarity and with a vertical resolution down to 30 Å. On the other hand, the lateral resolution so far obtained (400 Å) is not so good as with the replica methods used in transmission electron microscopy. An electron microscope of this type is now installed in the Cavendish Laboratory.

Another microscopy exhibit was that for which Messrs. D. Causley, G. O. Norrie, F. Roberts and J. Z. Young, of University College, London, were responsible. It consisted of an attachment to a flying-spot microscope, which enables a single count to be made per particle irrespective of the latter's size and shape. The attachment comprises a calcite beam splitter, a polarising cube, two photocells and a high-speed electronic counter. The calcite crystal permits the specimen to be scanned with twin spots, which are arranged one above the other. The photocells associated with these spots are connected in anti-coincidence and outputs from them can only be obtained when the lower spot is off the particle. Any output is taken to the counter as well as to a monitor tube where it is identified by a bright "pip." The apparatus can be used for automatically counting dust particles and bacteria.

Mr. L. R. O. Storey, of the Cavendish Laboratory, Cambridge, demonstrated records of the whistling atmospherics which are sometimes observed at frequencies below 15 kilocycles. These whistles, it was pointed out, appear to fall into two groups, one of which originates from the radio waves in a lightning flash comparatively near to the observer and, after travelling into the upper atmosphere and across the equator, is reflected along its original path. The other group is thought to originate in lightning flashes on the far side of the equator and to have made only a single journey. In both cases it is supposed there may be a sequence of whistles corresponding with waves which have been reflected backwards and forwards across the equator as many as ten times. These whistling atmospheres drop in pitch as they proceed, owing, it is thought, to the fact that the speed of radio waves depends upon their frequency. From a study of this phenomenon Mr. Storey concludes that the earth's atmosphere may extend to a distance of some 7,000 miles above the equator.

In illustrating the effect of an echo on a speaker, Messrs. E. C. Cherry and A. J. Fourcin, of the Imperial College of Science and Technology, showed that, if spoken words are played back through headphones, violent stuttering is produced in the operator at a certain fairly critical delay. Although this can be overcome by slowing up the rate of speaking it is replaced by drawling and word repetition. The experiment is one of a series which is being undertaken to study the properties of human beings as a source or terminal of communication systems.

THE IRON AND STEEL INSTITUTE.

(*Continued from page* 651.)

CONTINUING our report of the recent annual general meeting of the Iron and Steel Institute, held in London on April 30 and May 1, we now deal with the morning session of the second day.

QUENCH-AGEING OF IRON.

The first two papers on the agenda were taken together for discussion and both contributions were papers of the Metal Physics Committee of the Metallurgy (General) Division of the British Iron and Steel Research Association. The first was entitled "The Quench-Ageing of Iron," and was by Dr. Anna L. Tsou, Dr. J. Nutting and Dr. J. W. Menter. The authors stated that optical and electron microscopes had been used to follow the metallographic changes occurring during the precipitation of carbon from a supersaturated solid solution in α-iron over a range of ageing temperatures and times. An attempt had been made to identify the precipitates by electron diffraction methods. The results obtained had shown that precipitates formed at random throughout the grains and then grew preferentially at the sub-grain boundaries; at this stage they were plate-like in shape. After ageing at 300 deg. C., the precipitates were still plate-like in shape, but had the normal cementite structure. Ageing at still higher temperatures resulted in preferential growth at the ferrite grain boundaries, and eventually cementite films were formed.

The second paper, by Professor A. H. Cottrell and Dr. G. M. Leak, was entitled "Effect of Quench Ageing on Strain Ageing in Iron." The paper described work carried out in the University of Birmingham and the authors stated that their experiments had shown that the observed rate of strain ageing depended on the initial heat-treatment of the material. Freshly-quenched specimens, that had a maximum amount of carbon and nitrogen in solution, strain aged about five times faster than those which had been quench aged at temperatures (120 to 300 deg. C.) where most of the carbon and nitrogen were precipitated out of solution. The rate of strain ageing was closely related to the amounts of carbon and nitrogen in solution and to their rates of diffusion. The experimental results showed a simple proportionality between the initial rate of strain ageing and the concentration of dissolved solute; this accorded with the theoretical prediction. A suitable quench-ageing treatment, for example, at 200 deg. C., could reduce the amount of carbon in solution to such a low value that strain ageing due to carbon became extremely slow. On the other hand, in view of the relatively high solubility and diffusion rate of nitrogen, quench ageing should not be very effective in reducing strain ageing due to nitrogen. For making "non-ageing" steel, the best procedure would seem to be to remove the nitrogen from solution by the addition of an element such as aluminium, having a strong affinity for it, and to remove the carbon from solution by a preliminary heat-treatment at, say, 200 deg. C.

DISCUSSION.

Mr. B. B. Hundy, who opened the discussion, said that the paper by Professor Cottrell and Dr. Leak was an excellent piece of work which lent still more weight to the dislocation theory of strain ageing. One point which arose was that apparently when a freshly-quenched sample of iron was strained, all age hardening due to quench ageing was eliminated. This implied that straining prevented the precipitation of iron carbide or nitride, the solute atoms preferring to remain in solution. He was glad to see that the authors' work confirmed the necessity for adding aluminium, vanadium or titanium to stabilise the nitrogen and produce a non-ageing steel. In this connection, the normal cooling rates used in industry seemed to be low enough to give a non-ageing steel even without quench-ageing at a low temperature.

Mr. W. P. Rees stated that Dr. Tsou, Dr. Nutting and Dr. Menter had used the comparatively new techniques of electron microscopes and electron

diffraction methods for studying a problem on which a large amount of work has been done for many years but almost entirely on the basis of measuring the effect of ageing on physical properties. The finding of austenite in the grain boundaries of material quenched from 700 deg. C. was quite important. It was an effect which, in some ways, was contrary to accepted conceptions. As to the question of the possible migration of impurities to the boundaries, in work at the National Physical Laboratory on high purity irons it had been shown, in a paper published by the Institute, that oxygen appeared to migrate to the boundaries; it could not be seen by ordinary photographic methods, but its presence was shown up by a very marked effect on the strength of the grain boundaries. Similar effects had been found in iron-nitrogen and iron-phosphorus alloys. These elements had not been detected in the boundaries but their effects had been shown on the strength values. The metal became quite brittle; thus, temper brittleness, also appeared to be caused by this migration to the boundaries.

Mr. D. McLean suggested that in the work by Dr. Tsou, Dr. Nutting and Dr. Menter there might be an advantage in using picral, namely, picric acid dissolved in alcohol, rather than nitric acid dissolved in alcohol, as the etching agent.

The next speaker, Mr. P. Samuel, agreed with Mr. McLean that picral was slightly more satisfactory in regard to its etching characteristic in revealing the grain boundary and veining films in these irons. Nitric acid, however, also has possibilities.

In the course of his reply to the discussion, Dr. J. Nutting said, with regard to the point raised by Mr. McLean and Mr. Samuel, that picral might be a better etching agent than nitric acid. Using picral, however, the products were much more adherent to the surface than was the case when using nitric acid and it was necessary to clean the surface many times before the etching products could be eliminated. Professor A. H. Cottrell, in his reply, stated that Mr. Hundy had raised an interesting point: Would creating dislocations in the metal prevent precipitation of the carbon? Would the carbon go to the dislocations in preference? Experiments which Dr. Leak and he had carried out were designed to prevent that kind of precipitation. They had tried to arrange the number of dislocations and carbon atoms in such a manner that there was not enough carbon and nitrogen to go round among the dislocations. In the previous week, however, there had come to his notice some work done in Germany in which matters were the other way about. It had been arranged that there was an excessive amount of carbon and nitrogen in solution and not many dislocations, and the ageing behaviour had been followed by the electrical distance method. From the residual electrical resistance the German investigators had concluded that when the carbon atoms became concentrated within the vicinity of the dislocations they actually precipitated.

Temper-Brittleness in Steels.

The last four papers dealt with on Friday morning all referred to some aspect of temper-brittleness and were discussed jointly after presentation. The first paper was by Mr. B. C. Woodfine, of the University of Sheffield, and was entitled "Temper-Brittleness: A Critical Review of the Literature." He said that he had paid particular attention to papers published since 1944 and had found that several suggestions concerning temper-brittleness which had been advanced were not supported by the experimental results, and there was also a danger that the problem might become obscured by differences in nomenclature. It had been established, however, that embrittlement occurred in steels containing Cr, Mn, W, Mo and Ni, although steel which contained only Ni did not appear to be susceptible, and Mo, in combination with the other elements, might reduce the susceptibility. Sulphur and aluminium did not appear to affect temper-brittleness, and it did not occur in plain-carbon steels containing less than 0·6 per cent. of Mn. Temper-brittleness could not be detected by any of the normal etching reagents, although it was revealed by reagents based on picric acid and containing small traces of surface-active compounds. Temper-brittleness occurred in steels having a tempered martensitic microstructure, either on slow cooling from 650 deg. C., or on reheating in the range 350 to 650 deg. C. It reached a maximum after treatment between 475 deg. and 525 deg. C. Temper-brittleness did not occur to any appreciable extent above 600 deg. C., and could be removed from a susceptible steel by quenching from about 650 deg. C. Further experimental work was required to clarify a number of outstanding points relating to the occurrence and development of temper-brittleness.

Mr. Woodfine was also the author of the subsequent paper: "Some Aspects of Temper-Brittleness." He stated that his investigation had shown that a grain-boundary etch could be produced in temper-brittle steels by a simple aqueous solution of picric acid. The etching reagent produced grooves at both the austenite and ferrite boundaries and did not reveal a grain-boundary precipitate. Brittle fracture occurred in tempered specimens by cleavage across the ferrite grains, and, in temper-embrittled specimens by failure along the previously-existing austenite boundaries. The temper-embrittlement at 550 deg. and 575 deg. C. in a Ni-Cr steel reached a maximum and then decreased as the tempering time increased. Prolonged tempering of a Ni-Cr steel at 650 deg. C. reduced the subsequent temper-embrittlement. Increasing the grain size of a susceptible steel increased both the amount of subsequent temper-embrittlement and the rate of embrittlement. The addition of Ti to a Ni-Cr steel did not prevent temper-brittleness from occurring but appeared to increase the temper-embrittlement. A similar effect was found with aluminium. Temper-brittleness was not the result of a simple precipitation of compounds from solution in the ferrite; it was suggested that it could be explained by the segregation of solute atoms to the grain boundaries in both the austenite and the ferrite.

The third paper dealt with "Temper-Brittleness in High-Purity Iron-Base Alloys," and was by Professor A. Preece and Dr. R. D. Carter, and described work conducted at King's College, Newcastle-upon-Tyne. The authors stated that temper-brittleness had not been detected in a pure Fe-C or Fe-P-C alloy, but it occurred to a marked extent in iron-base alloys containing Cr or Mn, together with phosphorus and carbon. It also occurred slightly in almost phosphorus-free (less than 0·001 per cent.) alloys containing high manganese or high chromium and carbon. Temper-brittleness could be detected by the etch test in Fe-Cr-P-C alloys containing as little as 0·4 per cent. of Cr and 0·014 per cent. of P, but in such alloys (containing no Mn) about 0·8 per cent. of Cr had to be present before the embrittlement change led to intercrystalline brittle fracture and a rise in transition temperature. On the basis of either weight or atomic percentage, the embrittling effect of Mn was appreciably greater than that of Cr. The presence of As in a phosphorus-free Fe-Cr-C alloy produced marked susceptibility.

The fourth paper, by Professor G. W. Austin, Dr. A. R. Entwisle and Mr. G. C. Smith, dealt with the "Effect of Arsenic and Antimony on Temper-Brittleness." The authors stated that the susceptibility of nickel-chromium steels to temper-brittleness was slightly increased by arsenic and greatly increased by antimony. Arsenic in the range 0·2 down to 0·02 per cent. had little effect on the tensile properties at room temperature, but the effect of antimony in the range 0·08 down to 0·005 per cent. depended upon the precise heat treatment given to the steel. Temper-brittleness could be regarded as a manifestation of the lowering of the grain-boundary brittle strength. It was suggested that temper-brittleness was due to the segregation of solute atoms to the grain boundaries while the steel was austenitic. These segregations were retained to a greater or lesser extent when the steel cooled to room temperature. Subsequent heat-treatment in the range 300 deg. C. to 600 deg. C., led to changes in the grain-boundary structure which resulted in the brittleness but the nature of the grain-boundary material was not known.

Discussion.

Dr. N. P. Allen, in opening the discussion on the four papers, emphasised that there was no single cause for temper-brittleness any more than there was a single cause for the proof stress of a metal. It was a characteristic which was varied by a great many factors, partly of composition and partly of heat treatment. The paper by Professor Preece and Dr. Carter was particularly useful in drawing attention to the very dangerous nature, from this point of view, of the combination of phosphorus and manganese and the combination of phosphorus and chromium, which had been suspected but not so clearly demonstrated. The demonstrations with regard to arsenic and antimony were equally valuable, but there were also a great many factors in heat treatment which were not fully realised. With regard to the explanation of the phenomenon, there were two opinions developing quite strongly. Everyone felt that it was something segregating to the grain boundaries which was the cause of the trouble. In the first opinion, it was postulated that a precipitate of something was obtained at the boundary and this formation or precipitate would explain the particular relations between phosphorus and manganese and phosphorus and chromium. The other explanation was that the impurity separated to the boundary but remained in solute solution in embrittlement because it was in solute solution above its normal amount. Apparently, there was no way of distinguishing between the two experimentally.

Mr. J. E. Russell stated that a difficulty connected with the segregation-at-the-grain-boundary theory was that the material which segregated at the pre-austenite grain boundaries must be able to move away from the grain boundaries at temperatures of about 650 deg. C., move to the grain boundaries at temperatures in the embrittling range of about 550 deg. C., and must be able to do that cyclically. A steel could be embrittled and toughened indefinitely more or less, hence material must be able to migrate to and from the grain boundaries more or less at will. He wondered whether some form of an order-disorder arrangement might not occur, namely, that, at about 650 deg. C., a complete disorder of alloying atoms occurred and that as the temperature dropped the atoms gradually became more and more ordered and this increase in the ordering implied an embrittling of the material. Dr. S. A. Main said that Mr. Woodfine's paper on the review of temper-brittleness had shown how very little progress had been made, after so many years, towards a knowledge of the real causes of temper-brittleness. As had been emphasised in the other papers and in the discussion so far, it was felt that much more progress ought to have been made if attention had been paid to certain fundamentals, for they would have thrown much light not only upon the question of temper-brittleness, but also upon what was happening, in general, in the hardening and tempering of steel. With reference to the breakdown of austenite, might it not be fairly assumed that the carbon in the austenite if it had been properly formed, namely, if it had had sufficient time for its formation, was extremely well diffused in solution? It might be, in fact, in a more or less atomic but not molecular state. That being so, it would appear in the martensite at the incidence of its production in that very highly subdivided form which chemists might call a nascent condition, and so in a very highly active chemical condition ready to combine with the iron or other carbide-forming elements. Naturally, such activity would depend, among other things, on the mobility of the atoms, which would naturally become more and more restricted as the temperature approached the atmospheric. It was possible that this point had not been borne in mind, and he believed that it should be.

Mr. D. McLean stated that temper-brittleness was one aspect of the problem of the tough-brittle transition which occurred in all ferritic materials that had been suitably tested. Two main rival theories had been put forward to explain the problem; they were the precipitate one and the segregate one. Discussing temper-brittleness in terms of segregation, it seemed that an interstitial element was likely to be the cause. That only a few elements were responsible was indicated by the fact that the damaging temperature in so many steels, namely, the temperature which produced a rather strong embrittlement in a given time, was in the neighbourhood of 500 deg. C., over a very

wide range of composition, suggesting that not very many different elements in all these different compositions were involved. It was natural to turn to carbon and nitrogen which were ever-present in steel. At first sight, the results obtained by Professor Preece and Dr. Carter with carburised samples appeared to support this, but there were complications which made it rather questionable whether this conclusion could or could not be drawn. On the other hand, the result of some work on plain-carbon steels suggested that carbon alone did not produce the effect.

Mr. A. L. Carr said that the paper by Professor Preece and Dr. Carter was of fundamental interest and value, because these investigators had used materials of high purity. It appeared, however, to be a very common occurrence that as alloys become purer, the effects of the slight amounts of impurities left became greater, and although the authors had gone to considerable trouble to control the oxygen content of their alloys, there might still be one or two other elements present which had a disturbing effect on the results. Temper-brittleness was attributed by them mainly to the presence of carbon, but their results did not conclusively demonstrate that the temper-brittleness effect was mainly due to carbon. Turning to the mechanism of embrittleness, all the authors seemed to agree that it was due to some form of segregation at grain boundaries. His own view of the process agreed more closely with that of the Cambridge investigators and was that the segregating elements were the trace-elements, such as arsenic, antimony, phosphorus or tin, and that antimony was of particular importance.

Owing to lack of time, the authors were requested to reply in writing, and the meeting was adjourned for luncheon. We intend to deal with the last session of the meeting in our next issue.

(To be continued.)

THE "STAMFORD" SELF-EXCITING ALTERNATOR.

THE recent demand for alternators with outputs not exceeding 100 kVA has led to the development of machines which are capable of generating a practically constant voltage under all conditions of load without the assistance of an automatic regulator. When such an alternator has only to supply a lighting or other non-inductive load at unity power factor the voltage can easily be maintained fairly constant either by the use of a series field winding, to which the line current is supplied through a rectifier, or by utilising the armature reaction. When, however, the load is inductive other methods of regulation must be adopted. These include the employment of specially constructed exciters or rotary compensators, with their attendant complications.

These drawbacks are overcome, it is claimed, in the alternators which are now being manufactured by Messrs. Arthur Lyon and Company (Engineers), Limited, Stamford. The method employed is applicable to both single and polyphase machines of either the revolving-armature or revolving-field types, although for outputs up to 75 kVA the former construction, using salient poles and the same frame as a corresponding direct-current machine with the commutator replaced by slip rings, is usually employed.

In design these alternators are basically the same as a level-compounded direct-current generator, although certain modifications are introduced to enable the excitation to be varied with both the load and the power factor. The necessity for this may be explained by reference to the simplified vector diagram reproduced in Fig. 1. In this diagram, in which the armature resistance, saturation and saliency of the poles are ignored, the vector O A represents the no-load excitation i_{nl}; the vector A D, the armature current I, at a power factor measured by D E corresponding to the phase angle ϕ, and the vector sum O D the excitation current, i, required to maintain constant voltage. If the armature current is constant, but the power factor is varying from unity to zero lagging, the locus of the currents I and i is the circle BDC with its centre at A. The required variation in the excitation current with the armature current and power factor, as shown in the diagram, is achieved by supplying the field winding of the alternator through a rectifier from two voltage components, one of which is proportional to the armature voltage and the other to the armature current. In practice, the phase angle between these voltage components is varied from 90 deg. at unity power factor to 0 deg. at zero power factor lagging by the method shown in the diagram reproduced in Fig. 2, which applies to a single-phase alternator. As will be seen from this diagram, the alternator armature has a main winding *a* and a coaxial auxiliary winding *b*, while the field has a single winding *c*. The latter is supplied from a bridge-connected selenium rectifier *d* through the regulator *e*, which is used to set the output voltage of the alternator. The input to the rectifier *d* is derived from a reverse series connection of the auxiliary winding *b* and the secondary winding of a current transformer *f*, the primary winding of which is excited by the line current.

Fig. 1.

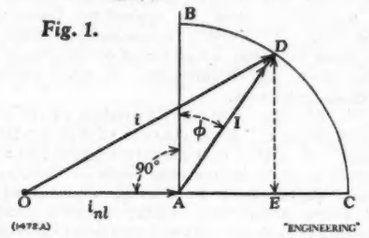
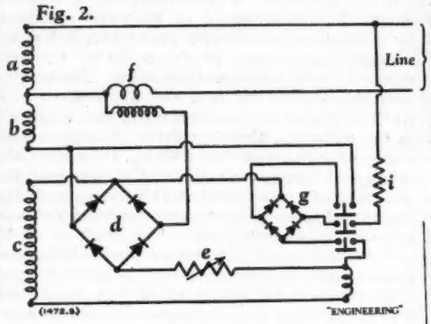


Fig. 2.



The auxiliary winding *b* (Fig. 2) generates the component for excitation which is proportional to and in phase with the line voltage, while the current transformer *f* generates the component which is proportional to the line current. The current transformer also produces the required phase difference of 90 deg. between the line current and its own secondary voltage, owing to an air gap in its magnetic circuit. This gap further ensures exact linearity between the primary current and the secondary voltage and can be adjusted so as to compensate the alternator for variations in the speed of the prime mover.

Such an arrangement will, within narrow limits, generate a constant line voltage at all loads and power factors between unity and zero lagging after the alternator has been initially externally excited and is kept running. It will not, however, be self-exciting, owing to the fact that the small residual voltage generated in the alternator before excitation begins will not overcome the inherent voltage drop in the rectifier due to the high forward resistance of the selenium. The method finally adopted to overcome this drawback is also shown in Fig. 2. It consists of a small bridge-connected auxiliary rectifier *g*, a triple-pole magnetic relay and a limiting resistance *i*. The rectifier *g* is designed for a much lower voltage than the main rectifier *d* and for an intermittent rating of very short duration. Its input side is connected through two relay contacts and the limiting resistance *i* to the armature windings *a* and *b* in series. Thus, the highest available residual voltage is applied to the rectifier *g* and self-excitation is, as a result, obtainable under any condition. The output side of the rectifier *g* is connected through the third relay contact and the relay coil to the field winding *c*.

When the alternator is started the relay contacts and the initiating circuit are closed. As the speed of the alternator, and therefore its residual voltage, increases, current will flow through the auxiliary rectifier *g* and the field winding *c* and excite the alternator. As soon as the field current, which also passes through the relay coil, reaches a value corresponding to no-load excitation, the relay opens the initiating circuit and excitation will be supplied by the main rectifier *d*. This arrangement has the advantages that the main excitation circuit is permanently in circuit and that the relay contacts, which are the only parts subject to wear and tarnishing, carry only a small current for a short time. The circuit for a three-phase alternator is essentially the same as that for a single-phase machine, the principal difference being that the armature winding *a*, the current transformer *f* and the main rectifier *d* are wound three-phase and the auxiliary winding *b* is replaced by a small three-phase transformer.

As regards construction, the alternator, a typical example of which is shown in Fig. 3, has a rotating armature. This has skewed slots and is lap wound with short chorded windings, which are connected both to the slip rings and to the salient-pole field system. The latter is built up as a separate assembly and pressed into the heated stator casing so that a shrink fit is obtained on cooling. Since there is only a single winding on both armature and poles, cooling presents no problem and, consequently, the weight of the machines, which are of the screen-protected drop-proof type, is usually small for the output. Both single and three-phase units with outputs of from 7½ to 40 kW at 50 or 60 cycles are available, while some machines can be arranged to supply three-phase current either at 415 volts and 50 cycles or at 208 volts and 60 cycles. The control gear is mounted on a switchgear panel with the meters, fuses, regulator and other auxiliaries.

Tests show that at varying loads, power factors and engine speeds the regulation of a three-phase machine is ± 1½ per cent. with speed variations of 4 per cent. This can be improved to ± 0·75 per cent. for special purposes. The figure for single-phase machines is slightly higher. Sufficient stability is also provided against violent voltage fluctuations with direct-on-line motor starting within the limits imposed by the prime mover, owing to the high momentary overload capacity of the machine. Synchronisation at both no-load and full load is possible, and the machines can be operated in parallel by cross-connecting the field windings.

SELF-EXCITING ALTERNATOR.

ARTHUR LYON & CO. (ENGINEERS), LTD., STAMFORD.

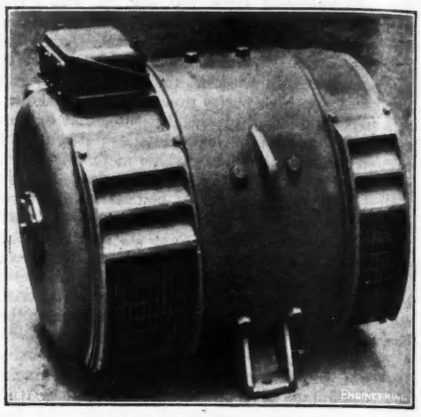
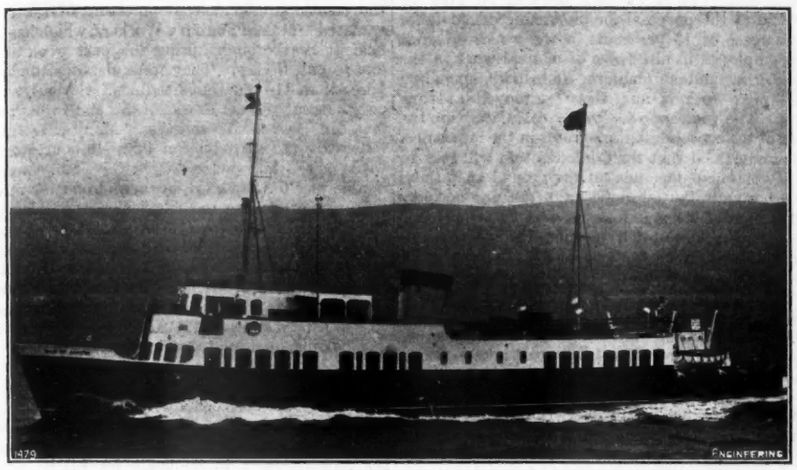


FIG. 3.

T.S.S. "MAID OF ASHTON."

YARROW & CO., LTD., GLASGOW.



"MAID OF ASHTON" FOR BRITISH RAILWAYS CLYDE COASTAL SERVICES.

THE Maid of Ashton is the first of four new twin-screw motor vessels (each of approximately 500 tons gross tonnage), and of three slightly larger vessels, to be built for the Clyde Coastal Services of British Railways under a 1*l.* million replacement scheme. This first vessel of the new fleet is illustrated above and has been built and fitted out by Yarrow and Company, Limited, Scotstoun, Glasgow. The Maid of Ashton has now entered the service of British Railways, having been launched on February 23 of this year and satisfactorily completed her trials on May 19. The ship had, in fact, been commissioned almost two weeks before the contract date.

The Maid of Ashton is built to the requirements of the Ministry of Transport for summer and winter passenger services, and, owing to the shallowness of some of the waters she will have to traverse, has been limited to a loaded draught of only 6·0 ft. She carries a crew of 14 and is designed to take 627 passengers. With an overall length of 165 ft., a breadth of 28 ft., a gross tonnage of 508, and engines developing a total of 1,300 h.p. at 425 r.p.m., her designed speed is 15 knots, with a service speed of 14 knots, and during trials a speed of over 14 knots was obtained with the engines turning at 375 r.p.m., at about 70 to 75 per cent. of their capacity.

The passenger accommodation centres on the main deck and includes an observation saloon forward, with large windows arranged to slide vertically. Aft of this saloon is a second saloon with a companion-way leading down to a third saloon immediately below; aft of the engine casing, and on the main deck, is a fourth saloon adjoining a refreshment room operating on the cafeteria system. Two 16-ft. lifeboats are carried in davits aft of the cafeteria on the main deck, and ten buoyant seats are located on the bridge deck immediately above. At the forward end of the bridge deck is the wheelhouse and the captain's cabin, the roof of which is reached by a stairway and serves as a landing platform to permit passengers to embark and disembark at Clyde piers at low tides. The saloons are attractively but, at the same time, serviceably finished and furnished, and all woodwork has received a transparent heat-proof plastic coating.

Before the keel was laid, extensive model tests were carried out at the National Physical Laboratory, Teddington, special attention being given to the steering and manœuvring qualities of the vessel; two rudders of the balanced type are fitted, and are operated from the wheelhouse by combined power and hand electric-hydraulic steering gear. The deck machinery includes an electric windlass fitted with a drum on each side for warping purposes, and there is also an electric warping capstan fitted aft. In order to reduce top weight, the outer funnel, which houses the main and auxiliary silencers and the draught vents from the engine room, is fabricated in aluminium.

The main propelling machinery consists of two six-cylinder M.46.I engines manufactured by British Polar Engines, Limited, Govan, Glasgow, directly coupled to two four-bladed bronze propellers. The propeller shafts are supported in white-metal bearings and run in an oil bath sealed by Newark glands at the outboard ends, Cooper roller bearings being fitted at the inboard ends. Each engine is of the two-stroke single-acting solid-injection type and is directly reversible. The bore and stroke are 250 mm. and 420 mm., respectively, and at 425 r.p.m. the piston speed is 1,172 ft. per minute. The mean effective pressure is 80 lb. per square inch, and the maximum pressure 780 lb. per square inch. The total weight of each engine is approximately 18 tons. Cooling of the pistons is by oil and the water jackets use fresh water in conjunction with a sea-water heat exchanger.

For the ship's services, which include forced ventilation, three Russell Newbery 25-kW 220-volt direct-current four-cylinder Diesel generating sets are installed; these sets, of which one is a stand-by, run at 1,000 r.p.m. on the same grade of oil as is used by the main engines, the auxiliaries of which they also serve. The number of masts, and the positions of the riding lights on them, are in accordance with the Revised Collision Regulations of the Ministry of Transport, for passenger-carrying vessels. These revised regulations come into force on January 1, 1954.

COMBINED ELECTRIC GAS-TURBINE DRIVEN COMPRESSOR.—A rotary compressor which is to be installed in the nitric acid plant of a dynamite factory owned by African Explosives and Chemical Industries, Limited, is to be driven both by an electric motor and a gas turbine. The motor, which was manufactured by the General Electric Co., Ltd., Kingsway, London, W.C.2, is of the screen-protected type and has an output of 2,200 h.p. at 6·6 kV. It is designed to operate at unity power factor at an altitude of 5,400 ft., the maximum ambient temperature being 40 deg. C. The drive is through gearing which will increase the speed from 1,500 to 8,000 r.p.m. Axial ventilation will be employed and excitation will be obtained from direct-coupled main and auxiliary exciters. The turbine, which, like the compressor, is being manufactured by the Escher Wyss Engineering Works, Zurich, is designed to burn a fuel which is a by-product of the chemical plant, and will have an output of 1,530 h.p. Normally, the motor and turbine will operate in tandem, but the full output of the former will be required at starting and when the turbine is not in use.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

EXHIBITION OF HISTORIC BOOKS ON MACHINES.—Friday, May 1, to Sunday, August 30, at the Science Museum, South Kensington, London, S.W.7. (Telephone: KENsington 6371.) See also page 623, *ante*.

"LONDON ON WHEELS" EXHIBITION.—Wednesday, May 20, to Saturday, August 29. See page 691.

BATH AND WEST AGRICULTURAL SHOW.—Wednesday, June 3, to Saturday, June 6, at Bath. Organised by the Bath and West and Southern Counties Society, 3, Pierrepont-street, Bath. (Telephone: Bath 3010.)

POWDER METALLURGY EXHIBITION.—Monday, June 8, to Wednesday, June 10, at London. See page 678.

BRITISH PLASTICS EXHIBITION.—Monday, June 8, to Thursday, June 18, at Olympia, London, W.14. BRITISH PLASTICS CONVENTION.—Monday, June 8, to Wednesday, June 17, at Olympia. Organised by *British Plastics*, Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.) See also our issue of October 10, 1952, page 462; and page 466, *ante*.

BRITISH ELECTRICAL POWER CONVENTION EXHIBITION.—Monday, June 8, to Friday, June 12, at Torquay. Arranged by the British Electrical Development Association, 2, Savoy-hill, London, W.C.2. (Telephone: TEMple Bar 9434.) See also page 115, *ante*.

THREE COUNTIES AGRICULTURAL SHOW.—Tuesday, June 9, to Thursday, June 11, at The Racecourse, Hereford. For further particulars, apply to the Three Counties Agricultural Society, Berrington House, 2, St. Nicholas-street, Hereford. (Telephone: Hereford 3969.)

CONFERENCE ON HEAT-TREATMENT PRACTICE.—Monday, Tuesday and Wednesday, June 15, 16 and 17, at Ashorne Hill, near Leamington Spa. Organised by the British Iron and Steel Research Association, 11, Park-lane, London, W.1. (Telephone: GROsvenor 4751.) See also page 628, *ante*.

BUSINESS EFFICIENCY EXHIBITION.—Tuesday, June 16, to Friday, June 26, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13, Dowgate-hill, Cannon-street, London, E.C.4. (Telephone: CENtral 7771-2.)

SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Friday, June 19, to Friday, June 26, at Bingley Hall, Birmingham. Sponsored by the Birmingham Industrial Safety Group, 15, Old Town Close, Birmingham, 30. Further particulars obtainable from the exhibition secretary, Mr. A. G. Cogswell, Dunlop Rubber Co., Ltd., Fort Dunlop, Birmingham. (Telephone: Erdington 2121.)

ROYAL HIGHLAND SHOW.—Tuesday, June 23, to Friday, June 26, at Alloa. Organised by the Royal Highland and Agricultural Society of Scotland, 8, Eglington-crescent, Edinburgh, 12. (Telephone: Central 6106.)

INSTITUTION OF PRODUCTION ENGINEERS; BIENNIAL CONFERENCE.—Thursday, June 25, to Sunday, June 28, at Harrogate. Further information obtainable from the secretary of the Institution, 36, Portman-square, London, W.1. (Telephone: WELbeck 6813.) See also page 543, *ante*.

NOBEL PRIZE WINNERS IN PHYSICS: THIRD CONFERENCE.—Monday, June 29, to Thursday, July 2, at the theatre, Lindau, Lake Constance, Bavaria, Germany. Apply to Dr. F. K. Hein, Fischer-gasse 37, Lindau, Bodensee, Germany. See also page 655, *ante*.

SECOND BRITISH INSTRUMENT INDUSTRIES' EXHIBITION.—Tuesday, June 30, to Saturday, July 11, at Olympia, London, W.14. Apply to F. W. Bridges & Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

ROYAL AGRICULTURAL SHOW.—Tuesday, July 7, to Friday, July 10, at Stanley Park, Blackpool. Organised by the Royal Agricultural Society of England, 16, Bedford-square, London, W.C.1. (Telephone: MUSeum 5905.)

INDUSTRIAL CO-PARTNERSHIP ASSOCIATION, SUMMER CONFERENCE.—Friday, July 10, to Monday, July 13, at Somerville College, Oxford. Apply to the secretary of the Association, 36, Victoria-street, London, S.W.1. (Telephone: ABBey 3342.)

SUMMER SCHOOL AND CONFERENCE ON THE PLASTIC DEFORMATION OF METALS.—Monday, July 13, to Thursday, July 16, at Bristol. For further particulars, see page 678.

GREAT YORKSHIRE AGRICULTURAL SHOW.—Tuesday, July 14, to Thursday, July 16, at Harrogate. Apply to the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. (Telephone: York 3102.)

SUMMER SCHOOL ON THE SOLID STATE AND HETEROGENEOUS CATALYSIS.—Wednesday, July 15, to Wednesday, July 22, at The University, Bristol. Applications

to be made to the director of the Department of Adult Education, The University, Bristol 8. (Telephone: Bristol 25071.) See also page 194, *ante*.

SEVENTH INTERNATIONAL CONGRESS OF RADIOLOGY.—Sunday, July 19, to Saturday, July 25, at Copenhagen. Further particulars obtainable from the secretary-general, Professor Flemming Nørgaard, Kommunehospitalet, Copenhagen, Denmark.

ROYAL WELSH SHOW.—Wednesday, July 22, to Saturday, July 25, at Cardiff. Arranged by the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. (Telephone: Aberystwyth 7551.)

SECOND INTERNATIONAL CONGRESS ON RHEOLOGY.—Sunday, July 26, to Friday, July 31, at St. Hilda's College, Oxford. Organised by the British Rheological Society, 140, Battersea Park-road, London, S.W.11, with the support of the Joint Commission on Rheology of the International Council of Scientific Unions. Applications to be made to Dr. G. W. Scott Blair, The University, Reading. (Telephone: Reading 4422.) See also page 250, *ante*.

THIRD INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING.—Sunday, August 16, to Tuesday, August 25, at Zürich and Lausanne. Apply to the secretary, Société Internationale de Mécanique des Sols et des Travaux de Fondations, Gloriastrasse 37, Zürich 44.

RADIO AND TELEVISION EXHIBITION.—Saturday, August 29, to Sunday, September 6, at Düsseldorf. *Agents:* John E. Buck and Co., 47, Brewer-street, London, W.1. (Telephone: GERrard 7576.)

NATIONAL RADIO SHOW.—Tuesday, September 1, to Saturday, September 12, at Earl's Court, London, S.W.5. Applications to the organisers, Radio Industries Council, 59, Russell-square, London, W.C.1. (Telephone: MUSeum 6901.)

BRITISH ASSOCIATION.—Wednesday, September 2, to Wednesday, September 9, at Liverpool. Applications to be made to the joint local secretaries: Mr. T. Alker, Municipal Buildings, Dale-street, Liverpool, 2. (Telephone: Central 8433); and Mr. S. Dumbell, O.B.E., University of Liverpool, Brownlow Hill, Liverpool, 3. (Telephone: Royal 6022.) See also page 214, *ante*.

BUILDING PLANT EXHIBITION.—Thursday, September 3, to Wednesday, September 9, on the Goole Fair site at Nottingham. Organised by the Ministry of Works, Lambeth Bridge House, Albert-embankment, London, S.E.1. (Telephone: RELiance 7611.)

19TH ENGINEERING, MARINE AND WELDING EXHIBITION AND CHEMICAL PLANT EXHIBITION.—Thursday, September 3, to Thursday, September 17, at Olympia, London, W.14. Apply to F. W. Bridges & Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. (Telephone: WHItehall 0568.)

AMERICAN CHEMICAL SOCIETY: 124TH NATIONAL MEETING.—Sunday, September 6, to Friday, September 11, at Chicago, Illinois. Apply to the secretary, American Chemical Society, 1155, 16th-street, Washington 6, D.C., U.S.A.

FORESTRY AND THE TIMBER INDUSTRIES CONGRESS.—Monday, September 7, to Saturday, September 12, at Stuttgart, Germany. Held under the auspices of the Organisation for European Economic Co-operation and the Mutual Security Agency. Apply to the secretary of the congress, Mr. Eberhard von Bernuth, Luisenstrasse 33, Bonn, Germany. See also page 664, *ante*.

INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING.—Monday, September 14, to Friday, September 18, at Scheveningen, Holland. For further particulars see page 703.

FOURTH ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—Monday, September 14, to Thursday, September 17, in London. Communications to the secretary, Royal Aeronautical Society, 4, Hamilton-place, London, W.1. (Telephone: GROsvenor 3515.) See also page 678.

PUBLIC LIGHTING CONFERENCE AND EXHIBITION.—Tuesday, September 15, to Friday, September 18, at Liverpool. Arranged by the Association of Public Lighting Engineers, 22, Surrey-street, London, W.C.2. (Telephone: TEMple Bar 9607.)

EIGHTH NATIONAL INSTRUMENT EXHIBIT.—Monday, September 21, to Friday, September 25, at the Sherman Hotel, Chicago. Organised by the Instrument Society of America, 921, Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

AMERICAN SOCIETY OF AUTOMOTIVE ENGINEERS: NATIONAL AERONAUTICAL MEETING, AIRCRAFT ENGINEERING DISPLAY AND AIRCRAFT PRODUCTION FORUM.—Wednesday, October 7, to Saturday, October 10, at Los Angeles, California. Apply to the secretary of the Society, 29, West 39th-street, New York 18, U.S.A.

FIFTH INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.—Friday, October 9, to Thursday, October 15, at Turin. Organised by the Associazione Industriali Metallurgici Meccanici Affini, Via Massena 20, Turin. Applications to be sent to the director, British Engineers' Association, 32, Victoria-street, London, S.W.1. (Telephone: ABBey 2141.) See also page 250, *ante*.

LABOUR NOTES.

OVERWHELMING support was given by the general council of the Confederation of Shipbuilding and Engineering Unions at their meeting at York on May 20 to the proposal for presenting demands for an increase of 15 per cent. in the wages of adult men employed in all grades of manual work in the engineering and shipbuilding industries, including both piece-workers and those employed at time rates. The increases are to be calculated on the basis of the consolidated time rates in the industries. It is understood that the Confederation will seek to justify the new demands on the ground that there have been substantial increases in the productivity and profits of these industries, and that there has been a rise in the cost of living since the last increases were granted in November, 1952. In respect of the claims put forward on that occasion, the 38 unions affiliated to the Confederation sought to obtain an extra 2*l*. a week for their members, and, after negotiations, the engineering employees received an advance of 7*s*. 4*d*. a week, and the shipbuilding employees an addition of 7*s*. 6*d*. a week.

Although carried by an "overwhelming majority," however, the proposals did not receive unanimous approval. Two amendments were moved to the original motion. The first, put forward by the National Union of General and Municipal Workers, asked that the claims should be for an equal amount for all manual employees in these industries, instead of for a percentage on their earnings. The second amendment was submitted by the United Patternmakers' Association, and took the form of a request to the Confederation's executive committee that they should make an immediate application to the employers for a "realistic" percentage increase, based on the consolidated rates and earnings in the two industries, as well as a further claim for extra payments for engineering and shipbuilding employees based on the annual increase in productivity in their industries.

This amendment also contained a clause asking that the Confederation's executive committee should be instructed to negotiate immediately for the introduction of cost-of-living sliding-scale agreements into the industries, and for the launching of a strong attack on the constantly-rising cost of living. The Amalgamated Engineering Union, the Electrical Trades Union, and the Amalgamated Union of Foundry Workers, which each control large numbers of votes in the Confederation, had all declared their support of the original motion, however, and the points raised by the two amendments were quickly defeated.

Claims for a 15 per cent. increase are to be presented to the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation immediately. If granted in full, about three million adult male engineering and shipbuilding employees would benefit from the claims; skilled operatives to the extent of about 1*l*. a week, and unskilled men by 17*s*. 6*d*. a week. The present minimum weekly consolidated time rates amount to 6*l*. 16*s*. for skilled operatives and to 5*l*. 18*s*. for labourers. It is estimated that the total cost of such increases to the industries would be in the region of 125 million pounds a year. As has been pointed out in connection with previous claims of this magnitude, the possibility has to be faced that, if conceded in full, some of the lesser firms in these industries, working on only small profit margins, might be forced to close. In this lies a danger to employment.

The annual conference of the Confederation is due to take place early in August and the affiliated unions would like to have answers from the employers' Federations in time for them to be discussed on that occasion, but it seems doubtful whether the negotiations necessary on claims of such a nature will have advanced sufficiently far by then for a definite answer to be returned. The Amalgamated Engineering Union has decided that a special meeting of its national committee shall be summoned if a reply from the employers' Federations is not received in time for the Confederation's conference.

Resolutions covering almost every section of the foundry industry were included in the agenda for the eighth annual delegate meeting of the Amalgamated Union of Foundry Workers, which has been held at Scarborough during the past week and is due to end to-day. They were classified under no fewer than 110 different headings. Several, as was only natural, related to wage rates and to payments for holidays and sickness. Many resolutions requested the introduction of a 40-hour working week, a shorter working week for young persons, double pay for Saturday work, and of more advantageous methods for the calculation of holiday pay. Two resolutions expressed appreciation of recent Parliamentary action on sections of the Garrett report on the foundry industry and asked for its further implementation. One resolution asked that the employers' Federation should be urged to fix "a safety margin of 1½ in. between the casting and box inside all plate pattern work."

In his presidential address to the conference on May 25, Mr. Archibald McDougall, the chairman of the union's executive council, stated that requests for increased productivity were rapidly becoming the stock answer to demands for higher wages. The report of the union's general secretary showed that, in addition to greatly increased productivity in the foundry industry, which had advanced by 44 per cent. during the past six years, there had been more redundancy. He realised that he had no complete blueprint ready as a short answer to all the country's economic and industrial ills, but was convinced that reduction of the nation's armament commitments and the export of British products to all nations willing to receive them would go far towards improving the country's future prospects.

Subjects covering an unusually wide field were discussed during the second week of the annual conference of the Amalgamated Engineering Union's national committee at Eastbourne. At the session on May 11, some alarm was expressed at the drift of workpeople from Wales to London. One delegate claimed that this was causing many problems and he urged that, to combat these difficulties, it was essential that new industries should be set up in areas where under-employment existed. It was emphasised that there was a special need for new trades in South Wales, to provide work for about twelve thousand employees at old-type steel and tin-plate establishments in that area, which were due shortly to be superseded by new plants requiring fewer operatives. The delegates agreed that the union's leaders should approach the Government on this question.

Overtime working came in for a good deal of criticism at the same session. One London delegate lamented that, owing to excesses in this direction, some engineering craftsmen had fallen into the habit of "living for work." He said it might well be that some men wanted overtime, but it was for the union's leaders to give guidance on this important matter. Meetings of the union's members should be arranged to convince them of the error of their ways and of the need for more discipline. In one works where he was employed, no one was permitted to work overtime and this had a very steadying influence. A resolution expressing concern at the working of overtime was passed unanimously. On May 12, the executive council was instructed to work more vigorously than ever for equal pay for equal work for women. At the final session, a resolution advocating a public campaign to reduce national service to 12 months from the age of 21 was given unanimous approval.

Fifteen hundred employees of Messrs. G. and J. Weir, Limited, Glasgow, staged a lightning strike on May 20 because they refused to work with a "lapsed" member of the A.E.U. The fitter concerned had been a member until 1948, when he left the firm to start on his own account. His application to re-join the A.E.U. was rejected.

OVER-CRANK GUILLOTINE SHEAR FOR PRECISION WORK.

JOSHUA BIGWOOD & SON, LTD., WOLVERHAMPTON.

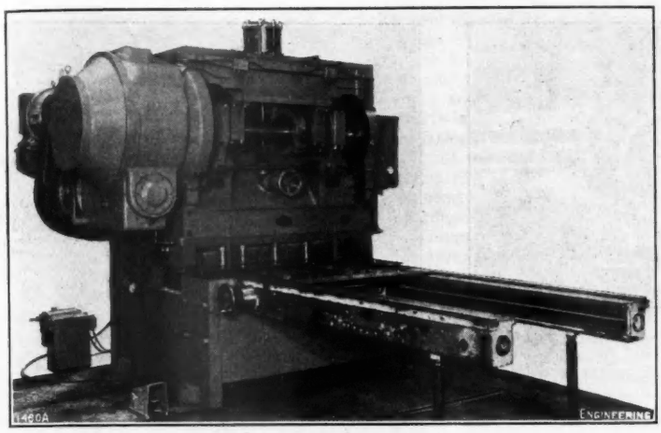


FIG. 1.

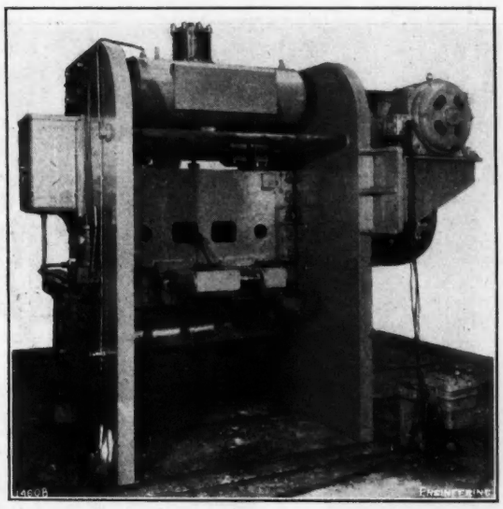


FIG. 2.

OVER-CRANK GUILLOTINE SHEAR FOR PRECISION WORK.

THE precision guillotine shear shown in the accompanying illustrations is one of a range made by Joshua Bigwood and Son, Limited, Wolverhampton, for shearing plate from $\frac{1}{16}$ in. to $\frac{3}{4}$ in. thick and from 4 ft. to 16 ft. wide. The machine illustrated is capable of dealing with mild-steel plate up to $\frac{5}{8}$ in. thick and 4 ft. wide. It is fitted with hydraulic hold-down gear, and adjustable back and front gauges are provided. The maximum speed is 25 strokes per minute.

The side frames are flame-cut from 4-in. steel slabs, and the principal compression members are of cast iron, of heavy box section. A crankshaft with two cranks, machined from a steel forging, is mounted in the side frames, with the clutch and drive assembly at one side and a hydraulic pump for operating the hold-down gear at the other. Two heavy inverted pedestal bearings are provided for the crankshaft, adjacent to the cranks, in addition to the end bearings in the frames, as shown in Fig. 1. The design of the machine is such that the crankshaft can be removed from the side frames and swung forwards for maintenance purposes—a feature which reduces the clearance space needed at the sides of the machine.

The drive is from a high slip-torque squirrel-cage electric motor of 18 h.p. running at 1,350 r.p.m. It is mounted at the rear of the machine (on the right of Fig. 2) and drives through V-belts a flywheel carried on a worm shaft. A spring-loaded slipping clutch is incorporated in the flywheel to protect the machine against damage from overloading. The worm engages a wormwheel which runs on a bearing on the crankshaft and is free to rotate thereon. One half of the driving clutch is mounted on the wormwheel. The worm, wormwheel and clutch are totally enclosed in the housing which is visible on the left-hand side of the machine in Fig. 1, and the assembly runs in oil. Hardened-steel tooth inserts are fitted to one side face of the wormwheel to form half of a multi-tooth dog clutch, and the second half of this clutch is in the form of a sliding sleeve, which is carried on a fixed member keyed to the crankshaft. The sleeve is splined internally, and the fixed member externally, so that the sleeve can slide in or out to engage or disengage the drive as required. Spring-loading ensures engagement of the sliding-sleeve teeth with those on the wormwheel, but a roller, running on a cam track, normally keeps the teeth out of engagement. To engage the drive, the clutch-operating lever is moved; this withdraws the roller, allowing the spring to move the sliding sleeve inwards until the teeth on the sleeve engage with those on the wormwheel. The crankshaft then commences to rotate, and the roller travels along the cam track. At the conclusion of one revolution, the cam track lifts the roller, and withdraws the teeth from engagement, so stopping the machine after a single stroke has been made. Clutch operation of the machine illustrated is by compressed air. A pedal, shrouded to prevent accidental operation, controls an air valve which admits air to a cylinder connected to the clutch lever. Compressed air for clutch operation is taken from the shop air-line at about 80 lb. per square inch, but if necessary a small air compressor can be supplied. Alternatively, the clutch can be controlled mechanically (by a conventional pedal) or by a solenoid.

Coupled to the crankshaft by two short connecting rods is the top beam, which carries the top shear blade and is balanced by means of an air cylinder. The air cylinder operates at 80 lb. per square inch, and an air receiver, which can be seen at the top in Fig. 2, is provided. As an alternative to compressed-air balancing, the top beam can be balanced by one or more heavy springs located in or on the cross-beam. The top, or upper, shear beam is guided by slide-ways, mounted on the side frames and provided with phosphor-bronze wearing strips. These are adjustable to compensate for wear. The slide-ways are so mounted that the beam moves at a slight angle to the vertical, and provision is made for quick and accurate adjustment of the shear-blade clearance. The slide-ways are carried on pivots at the top, and held by eccentric bushes at the bottom; rotation of these bushes swings the lower ends of the slide-ways in or out, and so changes the angle of travel of the beam, and the shear blade which it carries. The outer ends of the eccentric bushes, which project through the side frames, are provided with lock nuts, and with calibrated ring scales to show the position at which they are set. One of these adjusting points is visible immediately above the gap in the side frame of the machine in Fig. 1. It is advisable for the blade clearance of a guillotine shear to be set according to the thickness of the plate being cut, but if the setting is difficult or cumbersome it is frequently ignored by the operator, and the adjustment is only made when the blades are changed or re-ground. The method of adjustment adopted on the Bigwood machine makes it possible to alter the blade clearance quickly.

The shear blades are secured in machined ledges in the top and bottom beams, and are reversible, with four cutting edges. The upper blade is set at only a small angle to the horizontal, in order to increase the cutting accuracy and to reduce the tendency for the plate to move while shearing is in progress. This feature, coupled with the fact that the top blade moves with a slight backward rake, which eliminates any tendency for the plate to "skew," ensures a clean accurate cut, with a minimum of distortion. Provision is made, in the connection of the top beam with the crankshaft, to vary the effective height of the top shear blade. Eccentric wrist pins at the lower ends of the connecting rods enable the beam to be raised or lowered, and it is thus possible to set the top shear blade so that it does not completely overlap the bottom one at the end of the stroke. This setting is used for splitting plate which is longer than the blades.

On the side of the machine remote from the driving gear is a self-contained hydraulic unit, providing oil at a pressure of 500 lb. per square inch for the hold-down plungers. This combined pump and oil tank can be seen in both illustrations. The pump is driven by the crankshaft, and is set so that it works automatically when the shear is operated. When the crankshaft begins to rotate, the hydraulic pump comes into operation and sends oil under pressure to all the five hold-down plungers, so clamping the work before the shear blade makes contact with it. When the blade has made its full stroke, the hydraulic pressure is released automatically. The hold-down plungers can be fitted with non-abrasive pads when the nature of the material being cut makes it desirable.

Front and back gauges are provided, in a wide range of designs to suit various requirements. On the machine illustrated the gauges are hand-operated, with dial indicators to show the setting. The front gauge, which can be seen in Fig. 1, calls for no comment, except to say that the setting handwheel is visible immediately below the shear blade guard. A micrometer ring scale is provided to facilitate gauge-setting. The back gauge, which is carried on the top beam, can be seen in Fig. 2, while the handwheel which controls it is visible at the front of the machine in Fig. 1. The handwheel is located at a point at which it is accessible to the operator in his normal working position, and the necessity for going to the rear of the machine to set the gauge is obviated. The gauge is controlled by totally-enclosed screws, driven through an inclined shaft and universal joints from the handwheel at the front of the machine. A micrometer ring scale graduated in inches and $\frac{1}{32}$ in. is provided adjacent to the handwheel. It is thus possible to set the gauge to the nearest $\frac{1}{32}$ in. by direct reading, and by estimation (which is easy, since the graduations are widely spaced) to half this amount. As alternatives, there are several different types of back and front gauge available, ranging from simple, hand-set types, to power-driven gauges, with push-button controlled fast and slow movements. Magslip-operated dial indicators can also be fitted.

An adjustable band brake is fitted to the crankshaft to facilitate top dead-centre setting when the machine is being erected, or after overhauls. Lubrication of all bearing surfaces, except the worm drive is by a "Farval" centralised lubrication system made by Farvalube, Limited, Hereford.

POLYGONAL MACHINING ON A DRILLING MACHINE.

THOMAS CHATWIN & CO., BIRMINGHAM.

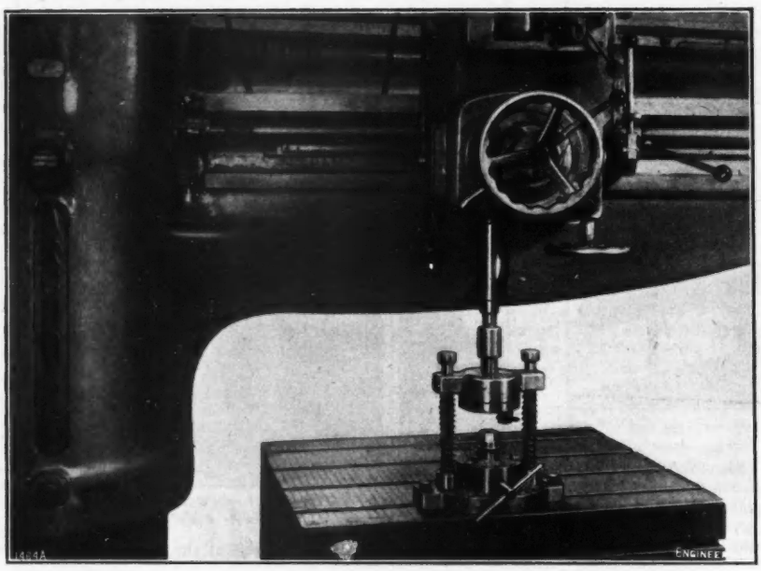


FIG. 1. MACHINING HEXAGON HEAD.

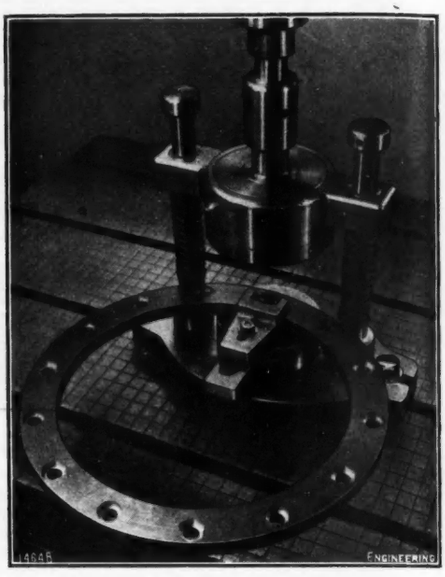


FIG. 2. BORING HEXAGON HOLES.

POLYGONAL MACHINING ON A DRILLING MACHINE.

IN 1946, Thomas Chatwin and Company, Victoria Works, Great Tindal-street, Birmingham, 16—a subsidiary of J. Brockhouse and Company, Limited—introduced their "polygon box," a toolbox which, by means of a rotary cam and follower, made possible the production of polygonal and irregular forms, from bar stock, in a lathe. A modified form of this toolbox has now been developed for use on a drilling machine, and is illustrated herewith. It is suitable for any drilling machine which can provide a spindle speed of approximately 200 r.p.m. and a feed of 0·001 in. per revolution. Figs. 1 and 2 show the new box in use, and indicate two different types of work which it is capable of doing; in Fig. 1, it is set up for external work, machining a hexagon head on a brass bolt, and Fig. 2 shows it boring hexagon holes in a steel ring. The toolbox is provided with a standard Morse taper socket for the drilling-machine spindle, and a baseplate which can be bolted to the machine table. Any suitable work-holding or clamping device can be mounted on the baseplate.

The operation of the toolbox can be followed from the drawings, Figs. 3, 4 and 5, on this page. Two pillars, *a*, mounted on the baseplate *b*, carry a body *c* which encloses the operating mechanism. Rotation of the Morse taper sleeve turns the spinner *d*, on which is mounted the tool-slide *e*. The tool-slide is provided with a cam follower *f* which is kept in contact with an internal face cam *g*. The cam is mounted and keyed in the body *c*, and, as the spinner and tool-holder assembly is turned, the follower is kept in contact with the cam face by two helical springs. The tool thus follows the path set for it by the cam, and as the body, spinner, and tool-holder assembly are traversed downwards by the machine feed, the tool produces the desired shape on the work clamped to the base-plate.

The cam is of hardened tool steel, and the follower is tipped with Stellite. Changing the cam to produce a different shape is simple. Removal of four Allen cap-head screws from the underside of the cover plate enables this component to be removed, complete with the tool slide. The cam is then accessible, and can be removed after six Allen grub-screws, bearing on its side, have been slackened. Dowels are provided to ensure alignment of the tool slide and cover-plate relative to the spinner. The cam shown in the drawing is designed for the machining of hexagons—internal or external, according to how the tool is mounted—but cams for squares, or for polygons with four or more sides, are available, and ovals, octagons, and many other shapes can be made. Any shape which it is possible to produce as an internal cam can be machined, internally or externally.

Fig. 3.

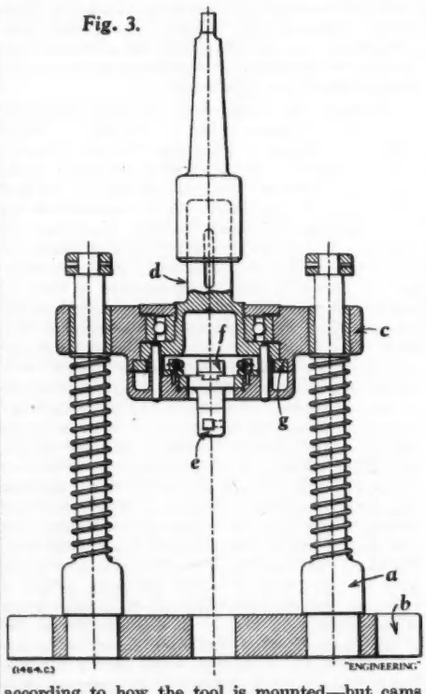


Fig. 4.

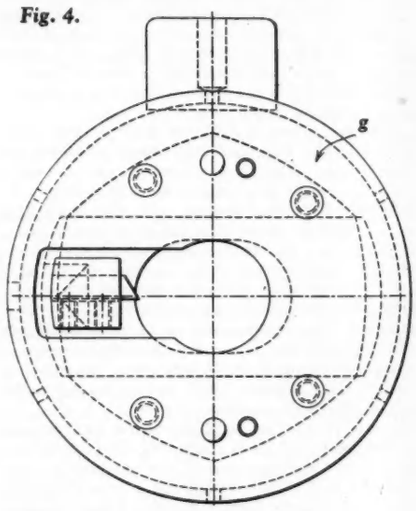
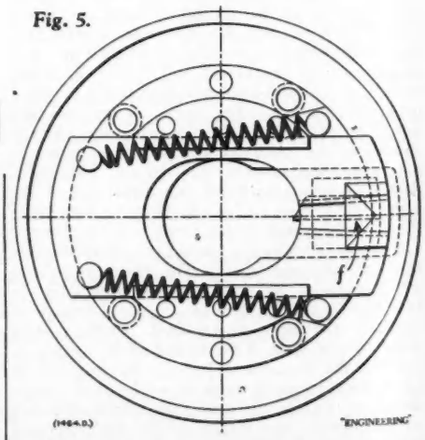


Fig. 5.



THE THEORY OF SUDDEN ENLARGEMENTS APPLIED TO POPPET EXHAUST VALVES.—Written discussion has been invited on a paper prepared by Boris N. Cole, Ph.D., B.Sc.(Eng.), Wh.Sch., and Brian Mills, Ph.D., for the Institution of Mechanical Engineers; communications on the paper should be received by the Institution before July 2. The paper shows that the simple theory of incompressible flow through a sudden enlargement can be extended to describe fully the compressible flow of a perfect gas. The flow properties of the poppet type of exhaust valve are examined on this basis and it is shown that the optimum design differs little from common practice. An appendix shows how the "blow-down" and scavenging periods may be separately analysed. The title of this paper is: "The Theory of Sudden Enlargements Applied to the Poppet Exhaust-Valve, with Special Reference to Exhaust-Pulse Scavenging."

GAS TURBINES IN RETROSPECT AND PROSPECT.*

By W. E. P. JOHNSON, A.F.C., C.P.A.

THE first practical gas turbine, the kitchen spit, was a "windmill" in the chimney. The pressure drop across this turbine was the chimney-draught; the heat was provided by the kitchen fire; the work done turned the spit through gearing. John Barber, of Leicester, in 1791, first systemised the idea in his Patent Specification, which showed an intellectual appreciation of modern gas turbine concepts in that it proposed a positive compressor, a controlled heat input and an expansion turbine, the last organised so as to do useful work.

In the Nineteenth Century, highly ingenious and partly practicable devices in which combustion takes place intermittently for discharge cyclically through valves, constituted the major part of invention. They belong to the "constant volume" school, which has failed to gain ground in half a century. In 1872, Stolze propounded the practical concept which we know to-day—the combination of axial compressor with axial turbine directly driving it, combustion chamber preceded by heat exchanger and (less classically) gas producer. Around the turn of the century there were many proponents of the constant-pressure cycle gas turbine, including Armengaud in France (1905) and Parsons in this country.

The technological shortcomings of the first 15 years of this century for gas turbines were metallurgical and aerodynamic. A change became evident around 1917, when Rateau and perhaps others began to think and act in the field of turbo-superchargers. In the '20s, Brown Boveri, entering the field under the influence of Stodola's conclusions but advancing on them, interested themselves in the special gas turbine case called the Velox boiler; and thence to turbo-superchargers and self-running gas turbines. The extent to which turbo-superchargers have contributed to the gas turbine is not readily apparent, but much that goes to make a good turbo-supercharger also goes to make a good gas turbine. When any question arises as to the potential reliability or serviceability of gas turbines, therefore, consideration should be given to the history of turbo-superchargers and their many examples with millions of hours of industrial running. A turbo-supercharger is a gas turbine with an intermediate combustion system comprised by a complete internal combustion engine.

Between the two wars, various industrial gas turbines were built and ran, and in some cases showed potential profit. In this chapter, the British engineering world showed some blameworthy conservatism. Swiss, American and slight German activity were seen. As far as I know, the first dividends were earned in America, by the gas turbines which served the Houdry oil-cracking process (1936). That this was a real and not a false start is shown by the continuous operation of these first machines and the continuous addition to them ever since.

The tardiness of the gas turbine's innovation is in some measure due to the fact that people who were held to be expert in compressor design, were, in fact, inexpert. It is not evident even to-day that compressors which should benefit from the technology evolved by gas-turbine scientists are, in fact, benefiting. In many rotary compressors, efficiencies and characteristics are unchanged since 1938. In my submission this is inexcusable. The application of 1948 technology to a compressor of 1938 size, weight and relative cost, could in many cases produce at least 10 per cent. more efficiency, and almost always a better characteristic.

In 1936 Whittle wanted a centrifugal compressor which would deliver, in one stage, between 30 lb. and 40 lb. of air per second with an efficiency of over 70 per cent. at a pressure ratio of 4. He was told by some of the contemporary experts that the absolute maximum he could get would be about 68 per cent. efficiency at a pressure ratio 2·8. When the experts were questioned as to why this was so, it emerged that they had never seriously applied aerodynamics to compressors. When the Whittle compressor was developed, it was immediately found possible to rely on 72 per cent. at 4; within the war period, compressors of the same basic design altered only in detail, gave a mass flow of about 42 lb. of air per second, a ratio of 4·1, an efficiency in some cases comfortably over 80 per cent., and an adequately uncritical characteristic. This was an example of the cross-fertilisation of technology. Whittle's approach was, in this case, that of the aerodynamicist: his thinking was mated with that of engineers who drew and stressed. In modern technological development, the interplay of different technologies is essential. It may be observed here that the gas turbine as a system involves perhaps a more intricate technical heredity than almost any other mechanism. The immediate pre-war and war periods of progress demonstrate this very clearly. There was no good gas turbine until the experience and thinking of experts in each of the fields of aerodynamics, thermodynamics, mechanics, thermochemistry, fuel technology and metallurgy were co-ordinated. Moreover, each of the technologies involved themselves gained by the stimulus they derived from gas turbine development. Thus we have seen small but significant changes in steam turbine design, a new outlook on high intensity combustion, new knowledge on ash separation, new high temperature alloys, and great advances in applied aerodynamics all flowing back from gas turbine development.

The real impetus in gas turbine development was the jet aero engine, which required no expensive and elaborate test rigs with brakes and cooling, no heavy foundations or buildings, and offered no practical fire risk. The type of engine on which the early work was done was often completely stripped, modified, and reassembled within 24 hours by four or five men. Such advantages collectively resulted in a very high rate of intellectual turnover.

During the war it was often said that no aero-engine could adduce anything useful to industrial engines because the requirements were entirely different. What nonsense! What is learned in regard (shall we say) to lightening an aero engine without sacrifice of life, is obviously applicable to an industrial engine if lightness be sought in the latter. What is achieved in extending the life of an aero-engine turbine blade is applicable in a marine engine. Industrial engineering has still a great deal to learn from gas turbine aero engineers: and the converse is also true.

Between 1936 and 1946 little industrial development was going on. In Switzerland, knowledge and experience were progressing, and some construction, handicapped by material shortage, was to be seen. At the end of this war period there were still very few industrial gas turbines in operation, except the Houdry plant machines in U.S.A.

I constantly hear that no industrial plant can be acceptable unless it has a life of 100,000 hours. No mechanical prime mover yet has had a life of 100,000 hours' continuous operation without major replacement. If, however, the life of an engine means the period during which it can economically be kept in service, then the problem is not mechanical so much as fiscal. In other words, when a "life" of 100,000 hours is stipulated, the true meaning is that the user is prepared to amortise the engine completely after he has extracted those hours; but presumably if at the end of 50,000 hours he could replace it by another of half the cost, twice the efficiency and half the maintenance, he would do so. The real criteria are reliability, operational economy and capital cost. If an engine cost 1*l*. per horse-power and would run with certainty for 8,000 hours (or about an operational year) then it would obviously be better to buy twelve of them to serve 96,000 hours (capital outlay 12*l*. per horse-power) than to pay 15*l*. per horse-power for 96,000 hours out of one engine which would require refit, say, every 16,000 hours.

Turbo-superchargers, which are low-rated gas turbines minus combustion chamber, have a very good history of reliability and durability. The combustion chamber remains therefore one questionable matter, and raising the rating is another. As to combustion chambers, the problem of reliability or durability is less than with steam generators, and the cost and speed of replacement of combustion equipment is intrinsically far less than the steam counterpart. Again, a gas turbine required for continuous service may be designed to have stand-by combustion equipment at relatively low capital cost so that maintenance could be provided for without shutdown. The effect of raising ratings is virtually entirely a metallurgical problem, and the effects to be considered are amenable to prediction. Progress in systems of blade and structure cooling may well repay by allowing higher operating temperatures for a given life and therefore higher efficiencies; or longer life for given operating conditions. Great strides have been, and are being, made in this respect.

In the immediate past the following are among the more conspicuous landmarks. An industrial gas turbine has done well over 20,000 hours, at an average overload of about 28 per cent. above its rating, with nothing but routine maintenance, and has incidentally generated well over 90,000,000 kW-hr. Another has propelled a ship for a couple of years and, when in for refit, has been dealt with in three days as compared with the three weeks allowed for its companion Diesel engines. Another is running as a generator at 32 per cent. thermal efficiency; yet another at about 36 per cent. In locomotives, the first to be used in regular freight service has, after several years of test, resulted in repeat orders of large magnitude. For pipeline pumping, many are in use and on order. Some twelve different species are known to be under active construction or development for road vehicles.

The simple "gas turbine system" comprises an air compressor, a combustion chamber through which the compressed air all flows and in which it is heated, and a turbine of which part (or all, in the jet engine) of the mechanical work output drives the compressor. Observe that any kind of compressor may be used; any amenable combustion system; and any kind of turbine. Thus the designer has an enormously wide field of selection. Not only the elements but also the cycle itself, are amenable to great variation. For example, consider the "inverted cycle." In this, hot gas, at atmospheric pressure if need be, is drawn through a turbine, is cooled, and is then recompressed up to atmosphere for discharge, the turbines driving the compressor. This cycle (which can be augmented by recuperation or by burning fuel in the gas before the turbine) has obvious possibilities for waste heat consumption. It will be big and clumsy, but it could be cheap, for its components are exposed to modest temperatures and the heat exchanger for cooling can obviously be of a low-grade type. It may be a source of power of fair efficiency, running on flue gas. If anyone has a stack exhausting at say 600 deg. C., and a good pond or river, they can get electricity. So, of course, could they by using steam; but I will wager that the cost of the current will be less by gas turbine.

If more complication be acceptable, the simple cycle is stepped up in efficiency if the air is heated before combustion, by otherwise-rejected exhaust heat. Compound cycles; compounded plus reheated cycles; intercooled compressors—all such expedients are open to selection. Not the least potentially important variant comprises compressor, heat exchanger, and turbine in that cyclic order, followed by combustion of fuel in the exhaust followed again by the input side of the heat exchanger. In this case no combustion products pass through the turbine. We may hope to see a locomotive burning coal and using this cycle before very long.

Let us refer by way of further example to a compressor shafted to a turbine, with heat input (either combustion or exchanger) between the two. This can result in (1) shaft power only, (2) shaft power and process heat, (3) shaft power from waste heat, (4) compressed air, (5) pressurised exothermic process.

There are centrifugal, axial-flow, semi-axial flow compressors (i.e., with both centrifugal and axial flow components). The free piston compressor has its adherents especially in France. Compounding

* Lecture given before the Society of Engineers on Monday, May 4. Abridged.

a gas turbine with an internal-combustion engine affords another means of compression.

Separate plural combustion chambers are classical for aero engines. Annular chambers are gaining popularity. "Canular" chambers are those with an annular air casing enclosing separate plural flame tubes. Cyclone chambers, especially for solid fuels, are under development. For closed-cycle systems a boiler-style furnace may be used. Most industrial plants are designed with large single chambers with refractory walls or with thin walls and air cooled metal flame-tubes. Turbines in use are axial flow, and inward radial-flow which look exactly like centrifugal compressor rotors. Tubular, plate-type, and rotary-regenerator type heat exchangers are all in use or under development. There are developments afoot in the use of molten metals or salts as heat-exchanger media.

With any or all of the foregoing and their derivatives, there may be combined steam-engine components, and there is a strong school of thought balanced between the use of steam generated by the waste heat of a gas turbine, and the use of a gas turbine in the waste heat of a steam set. A generating set on such lines can be designed to an overall efficiency of nearly 50 per cent. Other engineers are prepared to design a straight gas turbine system to yield well over 40 per cent. Perhaps we shall see a steam and gas plant in which good efficiency is obtained both at base and at peak load.

To-day, much intensive research work is going on in many countries on aerodynamics, metallurgy, heat transfer, and the physio-chemistry of combustion. The study of supersonic effects, especially in axial-flow compressors, and the possibility of using shock-wave compression, may result in greatly reducing the amount of blading required for a given pressure ratio, and consequently minimising the size and cost of compressors. The elimination of disturbances of flow, such as promote blade vibration, should prolong the life of machines. The aerodynamics of silencing and of ash separation are studied.

The metallurgist is concerned to produce materials of appropriate properties which can be worked and he is also involved in problems of heat transfer. Work is going on not only to find high-temperature materials for turbines but to select those best adapted to cooling systems or to evade corrosion, or to act as insulators and protection coatings. Great advances are being achieved in alloys of non-critical metals, in porous materials, and in ceramics which may result in whole blades or in protective coatings to enable low-grade materials to be used for mechanical strength within them.

Much remains to be done in reducing and cheapening heat exchangers, and immunising them from the effects of corrosion or incrustation. The problem of cooling turbine blades and combustion parts is equally important. There are many possibilities. Broadly, at present turbine blades can be cooled by direct external spraying with water or other liquid coolant (including fuel), externally or internally by water or air, and by methods involving porosity with coolant "sweating" through a wall.

In the early days the problem was to burn fuel in a fast-moving stream of greatly excess air, and to obtain a uniformly (unstratified) hot result, all with minimal pressure loss. To-day, the problem is to cope with applications rather than fundamentals. The ability to burn residual oil or coal; to separate fly-ash; to avoid chemical attack by combustion products on turbine blades—these are current matters of great importance. The last-named lies partly with the combustion expert and partly with the metallurgist.

The variety of designs at present to be seen is a good index not only of the magnitude of effort but its uncertainty. Well over 500,000 kW of industrial gas turbines exist or are under construction to-day. It is, however, possible to identify about 130 different types: of these, about 50 fall into the "under 1,000 kW" class. Some are in essence, though not in detail, engines which could be either aero or industrial. There is no such thing yet as "classic" design. Industrial gas-turbine projects are alive in the following countries: United Kingdom, United States, Canada, Sweden, Denmark, Holland, France, Switzerland, Italy and Japan.

Hardly a week passes without some new adaptation of the fundamental system of gas turbines—compression, heat exchange, turbo-expansion—occurring, from the use of a hitherto ignored fuel to some special chemical process. In some cases, it is a little difficult to see why a gas turbine should be better than some other engine: for example, there have been inquiries (which can be answered) from South America for a gas turbine to run on the waste of crushed sugar cane (bagasse) to enable a sugar factory to produce cold air for internal purposes; another for a plant to run on bought-out steam and produce compressed air, hot air, and chilled air, all as a central service; for a small engine to run on aluminium. Efforts to introduce the gas turbine in exothermic pressure-operating chemical processes include nitric acid production by the catalytic combustion of air and ammonia. The possibilities inherent in integrated steel works, by making blast-furnaces self-driving by using the sensible and chemical heat of their effluent directly useful for compression, are well known. It can be shown that great economy should result. Similar treatment may be accorded to open-hearth furnaces. Tonnage oxygen production is a wide-open and currently-active field for gas-turbine technology. The generation of power from the methane in coal-mine ventilation air is to be tried by treating the whole upcast as a combustible mixture.

The past swift history of the gas turbine, the enormous amount of effort going into it to-day, and its extraordinarily good performance to date, justify all the sober statements and many of the statements of pure faith, which have been made about it in the past. In prospect, I foresee gas turbines for power generation both at base and peak load, running on solid or liquid fuels and on waste or primary gases, and on atomic and waste heat, as lighter, cheaper and easier machines than their competitors. In some cases, they will be combined with steam and Diesel engines. I foresee them in mercantile ships, taking less space, and involving less maintenance; and (if someone can invent good reversing) with mechanical rather than electric transmission. I foresee them in locomotives, exhibiting their advantages of torque characteristic, ease of control, economy of weight and volume; again with mechanical transmission. Gas turbines are on their way into road transport. The dogma that they will be uneconomic in fuel presupposes a bad part-load performance which is not inherent. I expect soon to see a centrifugal-centripetal gas turbine yielding good efficiency at 15 to 20 per cent. of its full power, and only slightly less efficiency at 100 per cent.

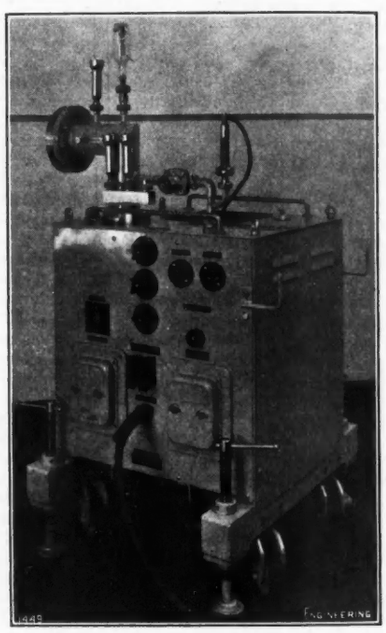
Their applications for outstation pumping and their use as natural-gas and methane burners is accepted. Their light and compact nature will bring them in for all manner of portable "power pack" uses, for forward field installation in civil engineering undertakings, in the oil fields, on estates. The possible military importance of portable power, quick starting and easy running is not overlooked. Other engines of war such as armoured fighting vehicles, are known to be under consideration.

There are many cases in chemical manufacture, in which gaseous processes are exothermic in nature, and either dependent on or amenable to pressurisation. Most such processes offer a use for gas turbines. A particular case under consideration, of petroleum chemical gas synthesis, wherein pressurised combustion is a starting point, and mechanisation of released thermal energy is incidental to the process, can only be practically achieved *via* a gas turbine. The thermal economy of pressure-still apparatus in low-temperature drying has been proved in some cases, notably that of wood-pulp drying. The same principles will be found to be directly applicable in many other currently extravagant processes, for example, in large-scale textile drying. The general principle here involves more compressor technique than the full gas-turbine cycle, but nevertheless, its success will be due to the gas-turbine engineers' contributions.

In a decade or two, an orthodoxy will be established. Suitable components to build into a huge variety of systems will be available "off the shelf." The concept of enormous single-unit plants may vanish, to be replaced by many relatively small machines, any one of which will be regarded as replaceable. The overall efficiency of such installations will be high over a very wide range of demand, and the general trend will be towards lower capital cost, less elaborate ancillary capital equipment and a higher rate of replacement.

PUMPING PLANT FOR HIGH-VACUUM TESTING.

THE accompanying illustration shows the smallest of a series of equipments which have been developed by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, for the high vacuum testing of vessels with volumes ranging from a few cubic centimetres to 5,000 litres. It consists of two diffusion pumps in series, backed by a 2·5 litres per second displacement rotary pump with the necessary vacuum valves for isolation



and control. Devices are also incorporated for protecting the plant against power and water failures; and gauge unions are provided which permit the use of any of the normal vacuum leak-detection techniques, in conjunction with either a Pirani hydrogen gauge or a differential Pirani gauge in which carbon dioxide is employed as the probe gas. The sensitivity is such that leaks of the order of 0·001 litre-microns per second can be detected, so that the inherent leakage rate of the system is much lower than that normally specified for continuously pumped equipments. The overall pump performance gives a pumping speed of 25 litres per second at pressures below 10^{-3} mm. of mercury and an ultimate pressure of about 10^{-6} mm. of mercury. As will be seen, the plant is totally enclosed and is mounted on castors. Screw jacks are provided for lining up the pump inlet flange with that of the vessel under test. All the controls are brought out to the front panel to facilitate operation.

PLOUGH FOR UNDEVELOPED COUNTRIES.—The Pendeford Engineering Co., Ltd., Alexandra-street, Wolverhampton, have designed a plough for use in undeveloped countries. Mr. J. P. Shorthouse, the managing director, saw ploughs in Egypt which were of a type used 3,000 years ago, and as it was obvious that normal mechanised-farming equipment was useless to a peasant farmer working 10 to 15 acres of land, he decided to produce a plough based on the ancient pattern, but of steel instead of wood. The Pendeford plough is therefore of a type with which the Egyptian peasant is familiar, and calls for no mechanical knowledge to use it.

170-B.H.P. MINES DIESEL LOCOMOTIVE.

HUNSLET ENGINE CO., LTD., LEEDS.

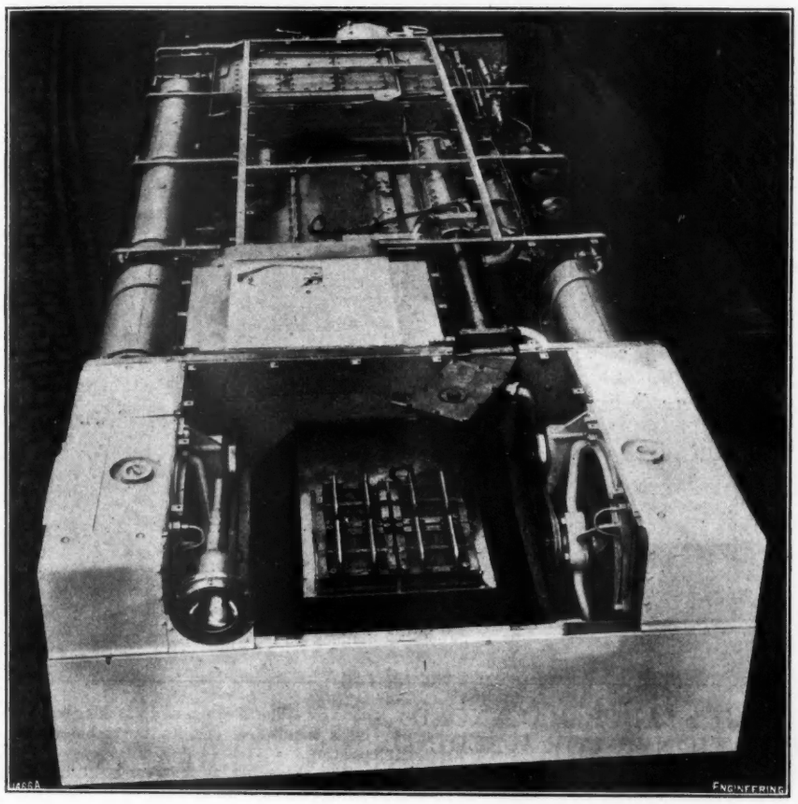


FIG. 1.

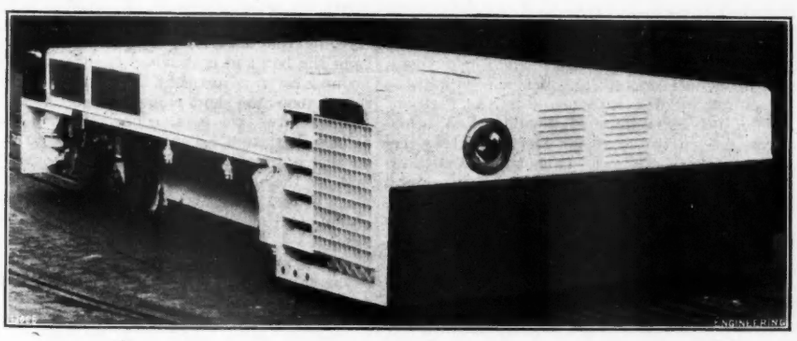


FIG. 2.

170-B.H.P. MINES DIESEL LOCOMOTIVE.

A MINES type of Diesel locomotive that is 7 ft. wide and only 39 in. high (15 in. or more lower than the conventional type of mines locomotive) and having a brake horse-power of 170, is shown in the accompanying illustrations. It has been designed for the North American market, where a width of 7 ft. is believed to be acceptable, as it is the custom there to cut only the coal seam, usually resulting in tunnels of low height and extreme width. The adoption of the Diesel in place of the electric-trolley type of locomotive, widely used in the United States, would allow the live trolley wires, which are hung at a low height, to be removed to prevent the accidents that are sometimes caused by them. The low height is achieved by fitting a horizontal type of oil engine and it gives the locomotive a very clean appearance. The general details of the design are in accordance with the requirements of United States Bureau of Mines Regulations. It is fully flameproof and is claimed to be the most powerful mines type of Diesel locomotive in the world. The makers are the Hunslet Engine Company, Limited, Jack-lane, Leeds, 10.

The frame structure is built of three main steel castings, together with steel-plate sections welded into one piece; this carries the engine and the gearbox on a direct mounting. Steel castings are used for the wheel centres, on to which are shrunk steel tyres 24 in. in diameter. The axleboxes are the S.K.F. roller type, and Tecalemit grease nipples are installed for general lubrication. The whole of the locomotive is covered by steel plates, which are made in sections for easy removal and replacement, to give access to the engine, gearbox, auxiliaries and air-brake equipment. The engine is made by Cummins Railroad Equipment Company, Incorporated, 271, Madison-avenue, New York, 16, whose agents in this country are John Blackwood Hodge and Company, Limited, 24, Berkeley-square, London, W.1. It has a four-stroke cycle and has six cylinders $5\frac{1}{8}$ in. in diameter, with a 6-in. stroke, giving a maximum output of 200 brake horse-power at 2,100 r.p.m. For use in this locomotive the fuel injector is set to give an output of 170 brake horse-power at 2,100 r.p.m. The six cylinders are in a single bank, and to suit the available space the crankshaft centre line has been off-set from the locomotive centre line. The front end of the engine is slung from a bridge piece, which forms one of the locomotive frame stays, and at the back it is carried by two solid feet. The fuel injection system is also made by the Cummins Company and is of the double-disc type. It embodies a low-pressure distributor-type fuel pump with a single plunger. The operating pressure in the fuel pipe-line is 120 to 180 lb. per square inch, and the injectors are fitted directly into the cylinder heads. The dry weight of the engine is 2,300 lb., its overall length is 64 in., width 55 in., and height 23 in.

The auxiliaries are all belt-driven. The radiators provided for the cooling water and engine oil have Serck elements and Hunslet header tanks, and are in two groups, one at each side, at the forward end of the locomotive, each having its own belt-driven fan. An electric immersion heater is fitted in the water tank to heat the circulating water in cold weather when the engine is shut down; this is necessary because many mines in the United States are of the drift type, and the locomotives come out into the open quite often. The heater uses current from an external source. Compressed air is employed for starting the engine, operating the brakes, sanding and whistling, and is supplied by a two-cylinder single-stage Bendix-Westinghouse compressor that is also belt-driven. Its capacity is 12 cub. ft. per minute at 90 lb. to 110 lb. pressure. The standard practice on this make of engine is to have one large oil-bath type of intake air filter covering the supply to all six cylinders, but for reasons of space, three Air-Maze oil-bath filters have been fitted.

To comply with the safety requirements of the United States Bureau of Mines for exhaust conditioning and flameproofing, a number of additions have been made to the standard installation. Firstly, the exhaust passes through a Hunslet patented conditioner of the jet type with a venturi attachment; this conditioner box is made of stainless steel and to eliminate any fire risk it is covered with asbestos and completely surrounded by steel sheet. A thermostatically-operated valve blows a whistle if the exhaust gets too hot, and a dial thermometer is fitted for direct temperature observation. The engine exhaust manifold is water-cooled; the exhaust pipe from manifold to conditioner box is water-jacketed; and the venturi equipment with auxiliary water tanks provides a water spray into the exhaust-gas stream. This equipment is not, however, sufficient to comply with Bureau of Mines requirements. Therefore the air-inlet manifolds have adaptors fitted, and are piped to an automatic vacuum valve, which operates a warning whistle when the vacuum becomes excessive. This fitting is thought to be desirable in case the flame-traps on the inlet side become choked, if for some reason regular cleaning is not carried out as required by their rules. Also the hand-operated throttle is fitted with interconnecting links to a slide valve in the air inlet, in such a manner that the slide valves can only be closed when the engine is shut down. The regulations also require a means to cut off the air supply to the engine to prevent it running on methane drawn from the atmosphere of the mine when the normal fuel-oil supply is closed. American requirements regarding flameproofing are much the same as those of the Buxton testing station of the Ministry of Fuel and Power, and stainless-steel flame traps are fitted to both intake and exhaust systems. Those for the exhaust are above the conditioner box and are located at the front of the locomotive, and are made accessible by lifting the front centre section of the main casing. The exhaust gas from the flame traps is mixed with air from the fans, and this mixture is then passed through baffles in front of the conditioner box before final ejection at the sides, where it is deflected downwards.

The transmission system of the locomotive uses a Hunslet friction clutch and a four-speed gearbox

having a preselector type of gear change, which is of the hand-operated air-assisted type. A jackshaft running on S.K.F. roller bearings carries the reversing bevels, and there is a rod drive to the wheels. The four gear steps give track speeds of 5½, 7, 9½ and 14 m.p.h., with respective tractive efforts of 11,000, 7,500, 5,700 and 3,850 lb. The weight in working order with 30 gallons of fuel in the tanks is 37,000 lb. On the 3-ft. 6-in. gauge, curves of 100 ft. radius can be traversed smoothly. Hand and Westinghouse straight air brakes are included, and provision is made for installing an automatic brake for the train.

CONTRACTS.

THE HUNSLET ENGINE CO. LTD., Hunslet Engine Works, Jack-lane, Leeds, 10, have received an order from the Nigerian Railways for six 3-ft. 6-in. gauge 0-8-0 tender-tank locomotives. The locomotives are of the standard 48½-ton type, with cylinders 18 in. in diameter and having a piston stroke of 23 in.

VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1, have received an order for a substantial quantity of twin-jet fighting aeroplanes developed from the Supermarine 508. The latter, the first twin-engined jet fighter designed for the Royal Navy, has satisfactorily completed deck-landing trials. It is powered by two Rolls-Royce Avon engines.

GILBERT GILKES & GORDON LTD., Kendal, Westmorland, have received an order for a 1,420-brake horse-power Turgo impulse wheel for the Avele hydro-electric scheme on the Pacific Island of Samoa. Another order is for two 720 brake horse-power Turgo impulse wheels for the Loch Dubh project, near Ullapool, of the North of Scotland Hydro-Electric Board; the wheels are being supplied through the main contractors BRUCE PEEBLES & CO., LTD. Further orders for water-turbines have been received for Mbabane, Swaziland, and Sasumua, near Nairobi, and for installation on the River Leven in north Lancashire.

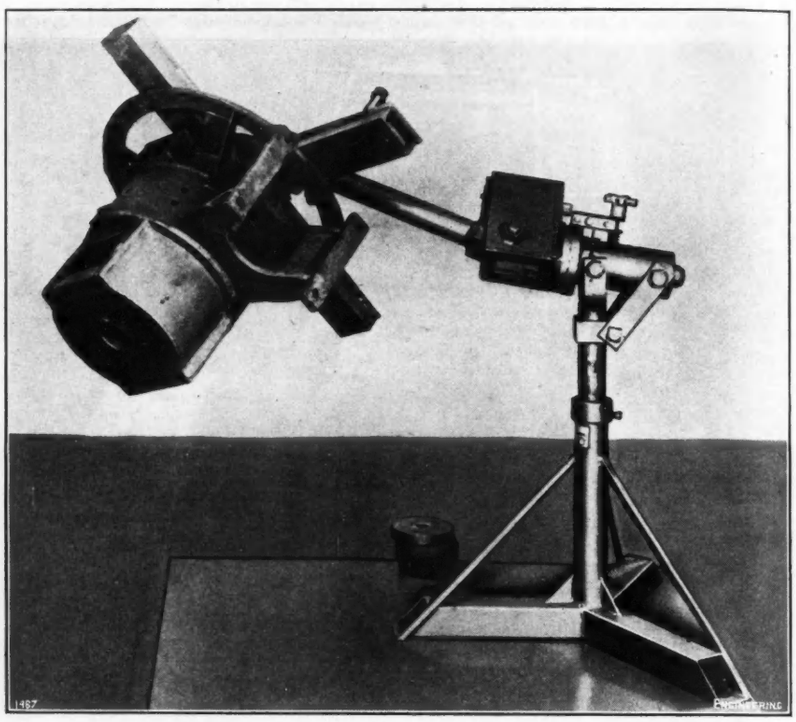
Contracts have been placed by the British Electricity Authority, during April, for equipment for power stations, transforming stations and transmission lines, amounting, in the aggregate, to 4,651,347*l*. The orders include, for Brunswick Wharf power station, Poplar, circulating water pipework, with AITON & CO., LTD.; for Tilbury power station, two generator transformers, with the ENGLISH ELECTRIC CO., LTD.; for Ince power station, near Ellesmere Port, the superstructure, with HOLLAND, HANNEN AND CUBITTS, LTD.; for Skelton Grange power station, Leeds, 11,000-volt and lower voltage cables and accessories, with DRAKE AND GORHAM (CONTRACTORS) LTD.; for Stella North power station, near Newcastle-upon-Tyne, three reinforced-concrete cooling towers and ancillary works, with the DAVENPORT ENGINEERING CO., LTD.; for Chadderton power station, Oldham, structural steelwork, with EDWARD WOOD & CO., LTD., and power, control and indication cables for two turbo-alternator sets, with ENFIELD CABLES LTD.; for Stella North power station and Huncoat power station, Accrington, brick chimneys, with P. C. RICHARDSON & CO. (MIDDLESBROUGH), LTD.; for Wymondley substation, Herts., 132 kV 1,500 MVA switchgear, with the ENGLISH ELECTRIC CO., LTD.; for Crumlin, Upper Boat and Ebbw Vale, uprating of 132 kV 1,500 MVA circuit breakers, with the METROPOLITAN-VICKERS ELECTRICAL CO., LTD., and 275 kV twin 0·4 sq. in. double-circuit overhead transmission lines for Iver to Melksham via West Weybridge, with BALFOUR BEATTY & CO., LTD.

British Railways have ordered the power equipments for 85 Diesel-electric shunting locomotives which are to be built in 1954 and 1955. This is an instalment in a five-year programme of 573 Diesel shunting locomotives covering the years 1953-57. The new contracts are for 45 equipments from the ENGLISH ELECTRIC CO., LTD., fitted with engines of their own manufacture, 15 equipments each from the BRITISH THOMSON-HOUSTON CO., LTD., and the GENERAL ELECTRIC CO., LTD., fitted with engines supplied by BLACKSTONE & CO., LTD.; and ten from CROMPTON PARKINSON LTD., fitted with CROSSLEY engines. The main frames, wheels, cab structures and mechanical parts of the locomotives will be manufactured and erected at the British Railways workshops at Darlington and Derby.

THE ENGLISH STEEL CORPORATION LTD., Sheffield, 9, are engaged on the production of a number of large steel castings required for plant to be built in the United States for the American defence programme. The heaviest castings weight about 170 tons, and some 210 tons of liquid steel are required for their production. A special road vehicle is being manufactured to convey the castings from Sheffield to the port of dispatch. The weight of vehicle and casting will be 230 tons.

S. P. AUSTIN AND SON, LTD., Sunderland, have received orders for three 4,600-ton colliers. One vessel is for Stephenson Clarke Ltd., and the other two are for William France, Fenwick & Co., Ltd., London.

ADJUSTABLE POSITIONER FOR WELDING.



ADJUSTABLE BALANCED POSITIONER FOR WELDING.

IT is often difficult to hold a component in the exact position desired for welding down-hand, yet this must be done if high-class welds are to be made. With this factor in mind, the Twinner-Aronson Universal Positioner shown in the accompanying illustration was designed by the Aronson Machine Company, in the United States, and it has received mention in the reports of the Anglo-American Council on Productivity. It is now supplied in this country by Messrs. Donald Ross and Partners, Limited, 1-3, Arlington-road, London, N.W.1, and is available in two sizes for carrying workpieces weighing 5 cwt. or 10 cwt. It is claimed that these machines make a considerable saving in capital and running costs when compared with the more conventional types of positioner. The main feature of the machine is its ability to bring a workpiece, not exceeding the load mentioned, into balance, so that it can be rotated by hand through a full 360 deg. both vertically and horizontally without any effort on the part of the welder. The arm of the work holder can also be swung 360 deg. around the centre supporting pillar. Thus it can be loaded in one position, swung through 90 deg. to another position for welding, and then through a further 90 deg. for unloading—a useful feature if the positioner is to be used on a production line.

The machine itself is of steel construction, with a tripod type of base drilled for bolting to the ground. A trolley base mounted on castoring wheels, which suits both models, is also made for mobile applications. The centre post is a steel tube, and a steel pillar fits into it and can be raised for height adjustment. A locking screw holds the pillar in position. Mounted above the pillar in a yoke-type bracket is the balancing mechanism and the support arm to which the work-table is attached. The table used on the smaller model is 6 in. diameter and it has four holes, for holding bolts, or clamps, $\frac{13}{16}$ in. in diameter on a pitch circle diameter of 3¾ in. It can be replaced by a 24-in diameter slotted table, or an adjustable cruciform type of holder, as shown in the illustration, made from steel channel; the arms of this holder can be adjusted from 36 in. across to 54 in. across as required. The pivot carrying the table is mounted on taper-roller bearings and a locking screw operated by a handwheel enables the table to be set in position.

The balancing mechanism is in the form of a worm and segment mounted in a box of heavy steel plate. It is fitted between the support arm and the short shaft which is carried in the yoke bracket above the centre pillar, to enable the angle of tilt on the support arm to be adjusted. The shaft carrying the worm has a square end protruding from the box and a standard spanner can be used for making an adjustment. Both the arm and box rotate about the short mounting shaft in a Timken bearing; two tie bars, connected from the end of this shaft to a collar, which is held in position on the centre pillar by locking screws, also makes possible the adjustment of the angle at which this shaft is set. By this means any workpiece may be balanced at the most desirable height from the ground. A counterweight attachment clamps on to the arm to bring extra deep workpieces into balance, but the combined weight of the workpiece and the counterweights must not exceed the capacity of the machine. A locking screw operated by a handwheel, and a quick-action locking pin which fits in any one of eight holes 45 deg. apart, are both provided for holding the arm in position.

To use the machine the workpiece must be clamped to the table with its centre of gravity on the centre line of rotation of the table. Then, by adjustment of the worm and segment, the angle of the arm is changed to bring the rotational axis of the arm into such a position that it will intersect the centre of gravity of the workpiece to produce balance in both planes. The workpiece can then be easily rotated into the position required for welding; to prevent this rotation from being too free, a friction pad is fitted to the worktable.

FAN ENGINEERING.—The Fan Manufacturers' Association are concerned at the small number of qualified engineers taking posts in the industry. The number of vacant posts are both many and varied in scope, and facilities for advanced training are now available at the National College for Heating, Ventilating, Refrigeration and Fan Engineering, which is established at the Borough Polytechnic, London, S.E.1. Further information can be obtained from the Association, at 59/62, High Holborn, London, W.C.1.

PRECISION SCRIBING AND LOFTING TABLE.

SHORT BROS. & HARLAND, LTD., BELFAST.

Fig. 1.

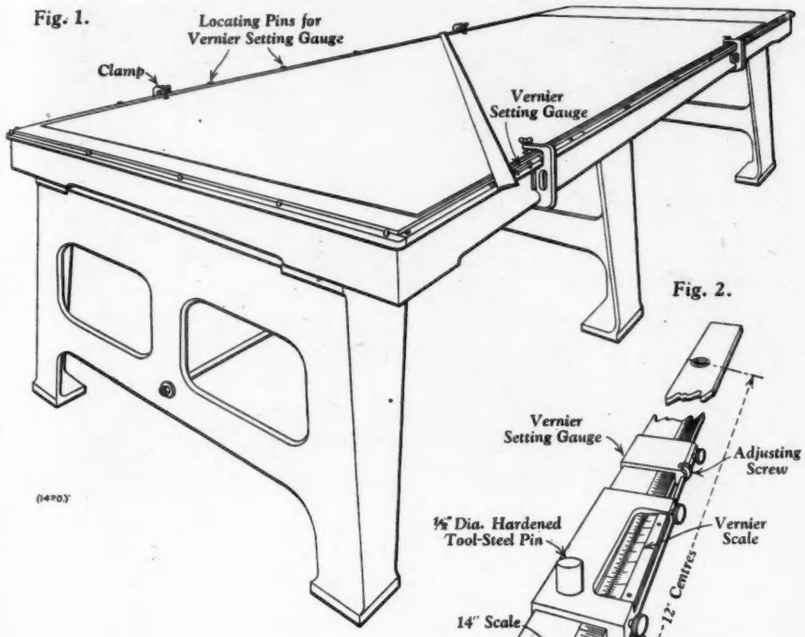
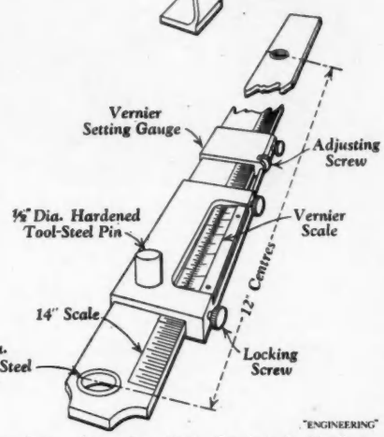


Fig. 2.



PRECISION SCRIBING AND LOFTING TABLE.

To provide a rapid method for carrying out layout and lofting processes to close tolerances in aircraft work, a precision scribing and lofting table has been developed by Messrs. Short Brothers and Harland, Limited, Belfast. The new lofting table, it is claimed, results in an overall saving of time of at least 60 per cent. in layout operations and inspection, and eliminates calculation errors. By the use of vernier gauges and a straight edge, a base grillage can be marked off and offsets can be set out at any required pitch to an accuracy of 0·001 in., enabling any required angle to be set up, by reference to a set of tables, without recourse to calculation.

The apparatus is shown in Figs. 1 and 2, above, applied to a 10-ft. by 4-ft. cast-iron surface table. (A wooden-topped loft table is equally suitable.) To the opposite sides and ends of the table are fitted 1-in. by ½-in. rectangular steel bars, along which ½-in. diameter pins are located in jig-bored holes accurately at 12-in. pitch. These pins serve to locate two vernier gauges (Fig. 2) on opposite sides or ends. The transverse pitch between the centres of the pins on the longitudinal members is set at exactly 50 in., providing a constant for determining the amount of offset between the readings of the vernier gauge on one side, relative to that on the opposite side, for setting out any required angle. A chart has been compiled from which the offsets for all angles between 0 deg. and 45 deg., in increments of 1 minute, are given. Locating holes fitted with hardened steel bushes are jig-bored on the vernier gauge at 12-in. centres, to mate with the locating pins. The gauge carries a 14-in. scale, graduated in $\frac{1}{10}$ in. divisions, the zero marking of which corresponds to the inner face of the hardened steel bush. The vernier cursor, graduated in 0·001 in. divisions, carries a ½-in. diameter hardened-steel pin, axially in line with the bush and the fixed steel locating pins, when the vernier is at the zero position.

In operation, the material to be marked out is clamped to the table by four specially-designed clamps which permit unrestricted movement of the verniers. Assuming that the longitudinal centre line is to be scribed, the vernier gauges are set in the central position at opposite ends of the table, with the vernier cursor set to zero. The straight edge is then located against the steel pins on the two cursors, automatically aligning the straight edge with the zero markings of the scale and vernier. Parallel lines and lines at right angles can be set out in a similar manner, using the appropriate locating pin. For scribing lines inclined to the datum, reference is made to the sine chart which gives the corresponding offset to which the vernier gauges must be set on opposite sides of the table; the straight edge position against the locating pins will give the required angle, and using linked parallels the line can be scribed through any desired point. Spring clamps are provided for securing the vernier gauges to the table.

In a modified version of the apparatus, the fixed locating pins are eliminated, and steel bars carrying scales marked with $\frac{1}{10}$ in. graduations extend over the full length and width of the table on all four sides. An independent cursor, similar to that already described, is fitted to each scale. This arrangement makes for easier manipulation and accuracy of setting when the precision layout table is permanently employed as an independent unit. The original peg-type table, however, facilitates the joining-up of groups of tables when it is desired to lay out large areas, by removing the adjacent end members and lining-up the tables with the end pegs set at 12-in. pitch. The large-area table has the advantage that lofting can be commenced simultaneously at several points without a progressive build-up of dimensional limits.

INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING.—Provisional arrangements for the autumn meeting of the Institution of Naval Architects have now been announced. The Council of the Institution has accepted an invitation from the Koninklijk Instituut van Ingenieurs for the meeting to be held at the Kurhaus, Scheveningen, Holland, from Monday, September 14, to Friday, September 18, 1953. Forms of application to attend may be obtained from the secretary of the Institution, 10, Upper Belgrave-street, London, S.W.1.

THE CIVIL ENGINEER IN THE LABORATORY.

IN 1828, at the time that a Royal Charter was granted to the Institution of Civil Engineers, Thomas Tredgold evolved a definition of civil engineering which was certainly comprehensive and which, in respect of some of its points, has proved to be prophetic. That definition began, "Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man; being that practical application of the most important principles of natural philosophy . . . which has changed the aspect and state of affairs in the whole world. The most important object in civil engineering is to improve the means of production and of traffic in States, both for external and internal trade." The definition continued with a comprehensive list of examples of the work of the civil engineer and was concluded all-embracingly as follows: "The real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors."

Professor A. J. Sutton Pippard, M.B.E., D.Sc., M.I.C.E., quoted this definition as an introduction to his subject, "The Civil Engineer in the Laboratory," when he gave the Friday-evening discourse at the Royal Institution, London, on Friday, May 8. Professor Pippard then described a variety of investigations, some particular to specific projects, that have been undertaken recently in his civil engineering laboratories at the Imperial College, South Kensington. The discourse was illustrated by models, slides and three films, the first—which has been broadcast in the B.B.C.'s television service—showing the technique of photo-elastic anal'ysis, the second showing tests on a model of the River Lyn, and the third showing tests conducted on a model of the overflow tunnel for a reservoir. Simultaneously, a small exhibition of models was staged in the library of the Institution, and some of these were used during the discourse.

Each of the models had been selected to illustrate one of the specific aspects of civil engineering referred to by Tredgold in the body of the definition quoted in part above. Thus, to represent general structural engineering, Professor Pippard employed a model representing a braced girder from which one of the lower horizontal members could be removed, the force in the member being replaced by those in two strings of a simple pulley system carrying a gravity load. With the assistance of this model, the lecturer was able to demonstrate both the Principle of Virtual Work. Clerk Maxwell's reciprocal theorem was demonstrated by means of a model of an unsymmetrical two-pinned arch, cut from a thin sheet of celluloid, to determine the abutment thrusts of the arch under load. As a particular example of the use of such models, he referred to an analysis of the stress distribution in the Dome of Discovery, built on the South Bank of the Thames for the Festival of Britain in 1951.

Turning to the problems in the design of gravity dams, Professor Pippard drew attention to the work of Mr. J. S. Wilson and Mr. W. Gore, who were the first, early in this century, to use india-rubber models for experimental studies of this type of structure. As a modern example of this type of investigation, he mentioned a model at Imperial College of a new dam that is being designed for the Government of Iraq by Messrs. Binnie, Deacon and Gourley, Westminster. As an example of river training, the lecturer described the model of the River Lyn, made for Mr. C. H. Dobbie, M.I.C.E., consulting engineer to the Devon River Board, as part of the investigation into the flood disaster of last year.

Professor Pippard concluded his discourse by pointing out that the civil engineer must steer a course between that of merely practising the errors of his predecessors and that of applying science, in the form of mathematics, where mathematics could not be applied. When such a course had been set and followed, then, as Tredgold had forecast, the bounds of civil engineering would be unlimited.

BOOKS RECEIVED.

Ministry of Transport. Railway Accidents. Report on the Collision which Occurred on 30th June, 1952, at Nottingham (Victoria Station) in the London Midland Region British Railways. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

Ship and Boat Builder Annual Review, 1953. John Trundell (Publishers) Limited, Temple Chambers, Temple-avenue, London, E.C.4. [Price 30*s.* net.]

Navigation Today. A Special Exhibition held at the Science Museum, London, from April-September, 1953. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

Numerical Solution of Differential Equations. By PROFESSOR WILLIAM EDMUND MILNE. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 6.50 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 52*s.* net.]

Technology of Engineering Materials. By B. RICHARD HILTON. Butterworths Scientific Publications, Bell-yard, Temple Bar, London, W.C.2. [Price 36*s.* net.]

Mechanics of Materials. By PROFESSORS SEIBERT FAIRMAN and CHESTER S. CUTSHALL. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 5.75 dols.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 46*s.* net.]

Nigeria. Annual Report of the British West African Meteorological Services, 1951. The Government Presses, Lagos, Kaduna, Enugu, and Ibadan; the C.M.S. Bookshops, Lagos and Port Harcourt; the S.I.M. Bookshop, Jos; and the Crown Agents for the Colonies, 4, Millbank, London, S.W.1. [Price 9*d.* net.]

Motion and Time Study Applications. By PROFESSOR RALPH M. BARNES. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 3 dols.]; and Chapman and Hall Limited, 37, Essex-street, London, W.C.2. [Price 24*s.* net.]

Materials Handling. By PROFESSOR JOHN R. IMMER. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6.75 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 57*s.* 6*d.*]

British Chemical Plant, 1953. British Chemical Plant Manufacturers Association, 14, Suffolk-street, London, S.W.1. [Limited issue available gratis to chemical plant users.]

Electro-Magnetic Machines. By PROFESSOR LANGLOIS-BERTHELOT. Translated and revised in collaboration with LIEUT.-COLONEL H. M. CLARKE. Macdonald and Company (Publishers) Limited, 16, Maddox-street, London, W.1. [Price 65*s.* net.]

Report to the President of the Board of Trade by the United Kingdom Trade Mission to Venezuela, Colombia, the Dominican Republic, Cuba and Mexico. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*s.* 6*d.* net.]

High-Temperature Alloys. By CLAUDE L. CLARK. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 60*s.* net.]

Permanent Magnets. Permanent Magnet Association, 301, Glossop-road, Sheffield 10. [Price 10*s.*]

Canada. Department of Mines and Technical Surveys. Mines Branch. Industrial Water Resources of Canada. Water Survey Report No. 1. *Scope, Procedure and Interpretation of Survey Studies.* By J. F. J. THOMAS. The Director, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada. [Price 75 cents.]

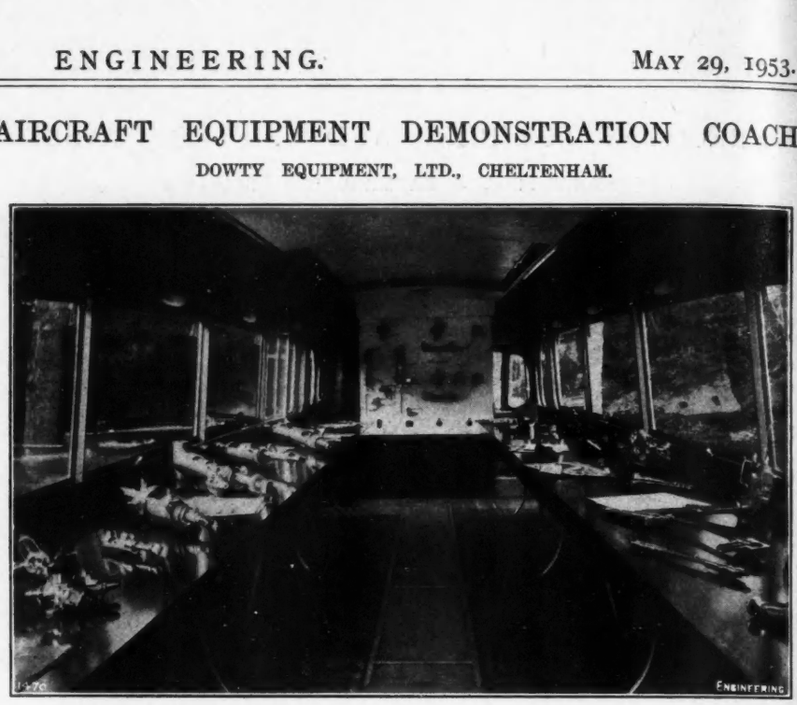
International Association for Bridge and Structural Engineering. Fourth Congress. Cambridge and London, 25 August-5 September, 1952. *Final Report.* The General Secretary, Professor P. Lardy, Swiss Federal Institute of Technology, Zurich.

Society of Chemical Industry. Chemical Engineering Group. Proceedings. Vol. XXXIII. 1951. Chemical Engineering Group, 56, Victoria-street, London, S.W.1. [Price 42*s.*]

The British Electrical and Allied Industries Research Association. Technical Report No. G/T271. *Flameproof Electrical Apparatus: Flanged Joints, One Half-Inch in Radial Breadth with Atmospheres of Normal Butyl Alcohol and Air.* By H. ROBINSON and H. L. WILLIAMS. [Price 10*s.* 6*d.*] No. G/T274. *Flameproof Electrical Apparatus: Flanged Joints, One Half Inch in Radial Breadth in Mixtures of Acetone Vapour and Air.* By H. ROBINSON, J. T. W. ROPER and H. L. WILLIAMS. [Price 10*s.* 6*d.*] No. G/T278. *The Ignition of Methane.-Air Gas Mixtures by Capacitive Spark Discharges.* By H. G. RIDDLESTONE. [Price 7*s.* 6*d.*] No. V/T105. *Deterioration of Insulation by Electrochemical Agents: Moisture Detection by Tests at Very Low Frequencies.* By DR. G. MOLE and D. C. G. SMITH. [Price 12*s.*] No. W/T23. *Pest Control by High-Frequency Electric Fields-Critical Résumé.* By A. MORRIS THOMAS. [Price 24*s.*] No. W/T26. *The Use of Electricity to Increase Soil Temperature.* By E. W. GOLDING. [Price 9*s.*] Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

AIRCRAFT EQUIPMENT DEMONSTRATION COACH.

DOWTY EQUIPMENT, LTD., CHELTENHAM.



TRADE PUBLICATIONS.

Pipework.—An illustrated pamphlet sent to us by Pipework and Engineering, Ltd., 115-119, West-street, Bedminster, Bristol, 3, shows some examples of the wide variety of this type of work that can be undertaken in their workshops. It includes a ship's gangway, a steam coil and special loops and bends.

Aircraft Engines.—We have received an illustrated leaflet from the Cirrus Engine Division, Blackburn and General Aircraft Ltd., Brough, East Yorkshire, giving brief particulars of their 100-h.p. Cirrus Minor, 158-h.p. Cirrus Major, and 180-h.p. Bombardier 702 engines for light aircraft.

Timing Relays.—Electrical Remote Control Co. Ltd., Elremco Works, East Industrial Estate, Harlow New Town, Essex, have issued a leaflet describing a new range of short-period timers for alternating-current and direct-current operation, including welding timers, conveyor-belt timers for sounding an alarm in the event of goods piling up on the belt, resistance cut-out timers for starting electric motors, and "make," "break," "delayed make," and "delayed break" timers.

Fluid Couplings.—We have received from Hydraulic Coupling Patents Ltd., Fluidrive Works, Worton-road, Isleworth, Middlesex, a booklet entitled "The Romance of Fluidrive," in which the history of the development of fluid couplings for marine, automobile and industrial drives is traced. Following a brief summary, the main portion of the booklet is devoted to an illustrated article by Professor G. Bauer entitled "Origin and Development of the Föttinger Transformer, Vulcan Coupling and Vulcan Gear."

Switches and Signal Lamps.—A detailed catalogue dealing with the numerous types of switches they manufacture, with capacities up to 10 amperes at 250 volts, and with signal lamps for voltages between 2 and 250 volts, has been received from Arcoelectric Switches Ltd., West Molesey, Surrey.

Water and Other Level Gauges.—Richard Klinger Ltd., Klingerit Works, Sidcup, Kent, have revised and republished the section of their catalogue concerned with level gauges. The new section contains full descriptions and illustrations of the company's level gauges for water, oil and liquefied gases, including high-pressure reflex level indicators for working pressures up to 6,000 lb. per square inch.

Electro-Magnetic Vibrating Units.—Podmores (Engineers) Ltd., Shelton, Stoke-on-Trent, have issued a pamphlet on their electro-magnetic vibrators. These small high-frequency units are designed to give up to 6,000 oscillations per minute on a 50-cycle alternating-current supply, and when attached to the outside of hoppers and chutes they ensure continuous flow. They can also be used in conjunction with sifters, spreaders and other types of machines which require to be vibrated.

Socket-Outlet Boxes and Switches.—MK Electric, Ltd., Wakefield-street, London, N.18, have issued particulars of their socket-outlet boxes and watertight switches.

Circlips.—We have received a number of illustrated leaflets from Anderton Springs, Ltd., Bingley, Yorkshire, which give details of the wide variety of standard and non-standard circlips made by them. Also included was a leaflet showing their "Maxigrip" tool for the removal and insertion of circlips.

DEMONSTRATION COACH FOR AIRCRAFT EQUIPMENT.

MESSRS. Dowty Equipment, Limited, Cheltenham, have recently fitted out a mobile showroom and exhibition coach for demonstrating their range of hydraulic, electrical and fuel-system equipment for aircraft. The bodywork, to the firm's special requirements, is by Duple Motor Bodies, Limited, The Hyde, London, N.W.9, and is mounted on a 5-ton Bedford chassis. The standard range of exhibits in the coach includes the main and nose-wheel undercarriage legs of a Hawker Sea Hawk aircraft, illustrating the telescopic and levered-suspension types, respectively. The accompanying illustration shows, on the left, a range of hydraulic jacks of various types for undercarriage, flap and dive-brake actuation. Electrical push-button switches, inertia switches, drum switches and indicators are also displayed, together with a range of Dowty synthetic-rubber seals, shrouds and diaphragms.

On the right-hand side of the coach is displayed hydraulic equipment, including a Vardel two-stage pump, and various control valves, sequence valves and pressure regulators. The fuel-system equipment on view comprises a 14-cylinder pump for a Sapphire engine, deliver ling,600 gallons per hour, a seven-cylinder pump for a Goblin engine, sectioned spill burners, and the fuel-metering assembly for the Ghost engine as installed in the Venom aircraft. At the forward end of the coach can be seen a hydraulic system in operation, comprising an undercarriage jack and fairing-door jack and the appropriate sequence valves and two flap jacks with "stepped" and "stepless" control, respectively.

CAST-IRON STOP-VALVE EXPLOSIONS.—Two fatal accidents have recently occurred due to the bursting of cast-iron stop-valve chests connected to boiler plant. One took place at the Old Brewery, Burton-on-Trent, and the other at Messrs. William Fiddes & Son, Ltd., Torry Sawmills, Aberdeen. In both cases the explosion was caused by water hammer, produced by the admission of steam to a section of the pipe line that had not previously been drained of the water of condensation. Examination of the valves, which were over 40 years old, showed no sign of previous fracture. One was of 6-in. bore with a wall thickness of approximately $\frac{11}{16}$ in., and the other was 5 in. bore and $\frac{3}{4}$ in. thick. In the latter case the valve body and cover were each fractured into three pieces, and in the former case the valve burst diagonally, to produce an opening 13 in. by 9 in. Reports of both these explosions have been produced by the Ministry of Transport, Marine Surveyor's Office, and copies are obtainable from H.M. Stationery Office, Kingsway, London, price 6*d.* The reports are Nos. 3366 and 3369, and were produced in accordance with the Boiler Explosions Acts, 1882 and 1890.